
Effects of Nurse Staffing on Processes of Care and Resident Outcomes in Nursing Homes: A Systematic Review

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The findings and conclusions in this document are those of the author(s) who are responsible for its contents and do not necessarily represent the views of the Department of Veterans Affairs or the United States government. Therefore, no statement in this article should be construed as an official position of the Department of Veterans Affairs. No investigators have any affiliations or financial involvement (eg, employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties) that conflict with material presented in the report.

PREFACE

The VA Evidence Synthesis Program (ESP) was established in 2007 to provide timely and accurate syntheses of targeted health care topics of importance to clinicians, managers, and policymakers as they work to improve the health and health care of Veterans. These reports help:

- Develop clinical policies informed by evidence;
- Implement effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- Set the direction for future research to address gaps in clinical knowledge.

The program comprises four ESP Centers across the US and a Coordinating Center located in Portland, Oregon. Center Directors are VA clinicians and recognized leaders in the field of evidence synthesis with close ties to the AHRQ Evidence-based Practice Center Program. The Coordinating Center was created to manage program operations, ensure methodological consistency and quality of products, interface with stakeholders, and address urgent evidence needs. To ensure responsiveness to the needs of decision-makers, the program is governed by a Steering Committee composed of health system leadership and researchers. The program solicits nominations for review topics several times a year via the [program website](#).

The present report was developed in response to a request from the Office of Nursing Services. The scope was further developed with input from Operational Partners (below), the ESP Coordinating Center, the review team, and the technical expert panel (TEP). The ESP consulted several technical and content experts in designing the research questions and review methodology. In seeking broad expertise and perspectives, divergent and conflicting opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Ultimately, however, research questions, design, methodologic approaches, and/or conclusions of the review may not necessarily represent the views of individual technical and content experts.

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Operational Partners

Operational partners are system-level stakeholders who help ensure relevance of the review topic to the VA, contribute to the development of and approve final project scope and timeframe for completion, provide feedback on the draft report, and provide consultation on strategies for dissemination of the report to the field and relevant groups.

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EXECUTIVE SUMMARY

INTRODUCTION

There are more than 1.3 million residents in over 15,000 US nursing homes. Nursing homes are complex environments serving a variety of resident needs, including rehabilitative post-acute, end-of-life, or custodial long-term care. Facilities may be stand-alone (independently owned or belonging to a network of facilities) or part of integrated care networks that include hospitals and clinics or continuing care communities. Nursing home residents have diverse care needs and diagnoses that vary within and across facilities. Within nursing homes, direct care nursing staff (*ie*, registered nurses [RN], licensed vocational or practical nurses [LPN], and nursing assistants [NA]) are the primary caregivers for residents; thus, the level and characteristics of nursing staff are likely to impact resident well-being, health, safety, and quality of life.

US nursing homes are governed by a complex regulatory and payment environment. While the Institute of Medicine recommends that there is at least 1 RN on duty 24 hours a day, federal regulations only require 1 RN on duty 8 hours a day and sufficient staff to provide nursing care to all residents. States can impose more stringent regulations but they also do not currently require that each nursing home has an RN on duty 24 hours per day. State regulations typically require specific nursing hours per resident per day (HPRD). There may be large daily variations in staffing levels in some facilities, and some evidence indicates that facilities may increase staffing to coincide with annual inspections.

The Department of Veterans Affairs (VA) operates 134 nursing homes, called Community Living Centers (CLCs), that together currently provide a total of 8,480 beds.¹ CLCs are often attached to VA medical centers or hospitals but may also be stand-alone facilities. Due to VA nurse staffing requirements, CLCs have higher levels of nurse staffing than non-VA community nursing homes. CLCs serve a variety of resident populations, which may have higher acuity and complexity of needs than residents in most non-VA community nursing homes. There is also a set of State Veterans Homes that are independently run by state governments. These State Veterans Homes must meet federal and state regulations for nursing homes, but do not follow the same VA nurse staffing requirements as CLCs. VA certifies that these State Veterans Homes meet certain standards and conducts annual surveys to make these determinations.

The VA Office of Nursing Services, in collaboration with Geriatrics and Extended Care, requested an evidence review on the effects of nurse staffing and skill mix on process of care and resident outcomes in nursing homes. The main goal of this review is to assist these VA partners with recommendations for nurse staffing at VA CLCs and State Veterans Homes. Here, we summarize evidence on effects of nurse staffing levels and skill mix, beginning with high-priority outcomes: pressure ulcers, nursing home-associated infections, and pain outcomes. For these outcomes, we also provide certainty of evidence for the summary findings. We then describe results for additional outcomes. Finally, we discuss implications of these results for VA policy and recommendations for future research.

METHODS

Key Questions

In collaboration with our VA stakeholders, we developed the following key questions (KQ):

KQ1: What are the effects of nursing home nurse staffing levels and staff mix on:

- a) Processes of care in nursing homes (*eg*, use of antipsychotics)?
- b) Resident outcomes in nursing homes (*eg*, falls)?

KQ2: Which nurse staffing levels and staff mix have demonstrated cost-effectiveness for improving resident outcomes?

Data Sources and Searches

We searched for peer-reviewed English language articles from January 2000 to May 2021 in the following databases: MEDLINE, Embase, CINAHL, and the Cochrane Database of Systematic Reviews. We used Medical Subject Headings (MeSH) and title/abstract terms for nurse staffing and nursing homes. We also hand-searched bibliographies of relevant systematic reviews, identified from searches of the above databases, VA ESP, and AHRQ Evidence-based Practice Centers. We conducted a grey literature search of websites of organizations that may produce potentially relevant reports or white papers.

Study Selection

After removal of duplicates and conference abstracts, citations were uploaded into DistillerSR. Eligible populations were adults (≥ 18 years of age) living in US nursing homes. Studies were excluded if evaluating other types of congregate settings (*eg*, homes for those with developmental disabilities or transitional housing for addiction treatment). Eligible articles addressed the effects of nurse staffing levels (*eg*, nurse hours per patient) or skill mix (*eg*, ratio of RN to other nursing staff) on processes of care (*eg*, receipt of antipsychotics and receipt or duration of urinary catheter) and/or resident outcomes (*eg*, pressure ulcers, nursing home-associated infections, and pain). Using these prespecified inclusion and exclusion criteria, titles and abstracts were screened by 2 reviewers. Articles included by either reviewer underwent full-text review. At full-text review, 2 individuals decided on inclusion/exclusion by consensus (input from a third reviewer was requested as needed).

Data Abstraction and Quality Assessment

Abstracted data from all eligible studies included the following: study design, setting and population characteristics, data sources, definitions of nurse staffing and/or skill mix, and processes of care or resident outcomes evaluated. For studies rated as moderate or high methodological quality, we also abstracted detailed results on the characteristics of staffing (amount and different types of nurse staffing, including total staffing [RN, LPN, and NA]); effects or associations between nurse staffing (or skill mix) and processes of care or resident outcomes; and detailed analytic methods (*eg*, consideration of confounders and analytic models). Data were abstracted by 1 person and over-read by a second. If needed to resolve conflicts, a third reviewer also evaluated the study.

Quality was independently assessed by 2 reviewers using a modified version of the Joanna Briggs Institute Critical Appraisal Tool Checklist for Analytical Cross-Sectional Studies. Generally, a study rated as having methodological concerns in 2 or more domains was considered low quality overall. Quality assessments were completed by 2 reviewers independently, and if needed, a third reviewer assisted with reaching consensus.

Synthesis and Certainty of Evidence

Due to heterogeneity in populations, methods, and outcomes of included studies, we performed qualitative synthesis of the results. We summarized key study findings categorized by the processes of care and/or resident outcomes being evaluated. For the 3 high-priority outcomes (pressure ulcers, nursing home-associated infections, and pain), we also rated overall certainty of evidence using a GRADE approach.

RESULTS

Overview of Eligible Studies

Of 9,152 unique titles and abstracts screened, 378 articles underwent full-text review, and 44 eligible studies were identified. We also searched 14 websites for grey literature but found no eligible reports for inclusion.

The outcomes most commonly evaluated by eligible studies were pressure ulcers (k=15), nursing home-associated infections (k=12), hospitalizations (k=9), residents with moderate to severe pain (k=7), and urinary catheters (k=7). Fourteen studies addressed multiple processes of care or resident outcomes. None of the eligible studies addressed cost effectiveness (KQ2). Nearly half of the studies used national US samples of NH (k=21) and were cross-sectional (k=24). Only 1 study addressed nurse staffing and resident outcomes in VA CLCs. Ten studies were high quality, 26 were moderate quality, and the remaining 8 were low quality. Methodological concerns across many studies included: accuracy of outcomes and staffing data (most were reported by nursing home staff or administrators); timing of outcomes assessment with respect to staffing measures (*eg*, outcomes may have been assessed before data collection on staffing levels); and adequate consideration of confounders. From the 36 high and moderate-quality studies, we abstracted detailed results on associations between nurse staffing and processes of care or resident outcomes.

First, we present results for key outcomes that were both high priority for our stakeholders and addressed by a sufficient number of studies: pressure ulcers, nursing home-associated infections, and pain (moderate to severe). We describe effects separately by different nurse staffing (*eg*, RN, LPN, or NA) or skill mix variables. We also present overall certainty of evidence for these results (using GRADE, see Methods). Then, we summarize results for the remaining outcomes.

Pressure Ulcers

Twelve moderate- and high-quality studies evaluated the association of pressure ulcers with nurse staffing. Nine studies were cross-sectional and 3 were longitudinal analyses. Though all 12 studies used data derived from the Minimum Data Set (MDS), measures of pressure sores and populations varied. One study specifically evaluated the number of residents with dementia who died with pressure ulcers (defined as having pressure ulcers on the last MDS before death). Most studies used data from years within 1999-2008. Six evaluated national samples of nursing homes, while the remaining used data from selected states. Sample sizes ranged from 63 to 14,618 nursing homes. Five studies were conducted by the same research team led by Castle, NG.

RN Staffing

Higher RN staffing is probably associated with fewer pressure ulcers among residents of nursing homes (moderate confidence). Among 11 studies addressing the relationship between RN staffing and pressure ulcers, 9 found that higher RN staffing was associated with fewer pressure ulcers. The remaining 2 studies found no association between RN staffing levels and the outcome of interest. Eight studies included conceptual models to inform their study design. Six studies conducted analyses adjusting for case mix and all studies adjusted for confounders such as environment, policy, and other staffing metrics. Five studies were conducted by Castle et al and all included conceptual models. The primary methodological limitation among all studies was uncertainty about whether measures of RN staffing had preceded assessment of the pressure ulcer outcomes. The magnitude of the association between RN staffing and pressure ulcers in nursing home residents is not clear.

LPN Staffing

Higher LPN staffing may be associated with fewer pressure ulcers (low certainty). Five moderate- and high-quality studies evaluated associations between LPN staffing and pressure ulcers. Four of these were from the same lead author (Castle, NG) and showed that higher LPN staffing was associated with fewer pressure ulcers. The fifth study found no association between measures of staffing and resident outcomes.

NA Staffing

Higher NA staffing may be associated with fewer pressure ulcers (low certainty). Seven studies examined associations between NA staffing and pressure ulcers. Four of these found that higher NA staffing was associated with a decrease in pressure ulcer presence. The remaining 3 studies found no association between NA staffing levels and the outcome of interest.

Total Staffing

Total staffing is probably not associated with pressure ulcers in nursing home residents (moderate certainty). Two moderate-quality studies evaluated total staffing and pressure ulcers in residents. One study examined pressure ulcers among high-risk patients in 162 nursing homes in New York, while the second study evaluated all residents of 1,142 nursing homes (national sample). The first study found no association between total staffing and the likelihood of pressure ulcers in high-risk residents (OR 1.11, $p=0.62$). The second study also did not find an association between total staffing and pressure ulcers (OR 1.01 [0.56, 1.82] among high-risk residents, OR 1.21 [0.58, 2.53] among low-risk residents).

Nurse Skill Mix

Higher skill mix may be associated with less pressure ulcers among residents (low confidence). Six studies evaluated skill mix as the ratio of RN staffing to total staffing. Three of the studies included a conceptual model to inform their study and analytic design. Four of the studies adjusted for case mix, and all studies included other confounders such as environment, policy, and other nursing home characteristics. Three studies reported no significant association, and the other 3 reported significant associations between nurse skill mix and pressure ulcers.

Nursing Home-associated Infections

Ten moderate- and high-quality studies examined nursing home associated infections. We first present results for COVID-19 outcomes, followed by other infections (eg, urinary tract infection [UTI]).

COVID-19 Cases and Mortality

Three high-quality studies and 1 moderate-quality study evaluated the association between nurse staffing and COVID-19 cases and/or mortality. Three studies were cross-sectional and 1 used repeated time series analyses. Two studies evaluated nursing homes within a single state, while 1 study looked at nursing homes in 17 states, and the fourth looked at national data. All the studies obtained staffing data from the CMS Payroll-Based Journal. COVID-19 outcome data were obtained from a variety of federal, state, county and news organization sources. Methodological concerns for all of these studies were mainly regarding accuracy of data for COVID-19 outcomes reporting, timing of nursing home staffing data versus COVID-19 outcomes, and possible staff shortages due to COVID-19 outbreaks.

Across the 4 studies, RN HPRD ranged from 0.49 to 0.75. Total staffing was evaluated in 2 studies, with mean HPRD 3.9 in one, and 55% of nursing homes < 4.1 total nurse HPRD in the other.^{13,14} Only 1 study examined relationships between NA staffing (mean HPRD 2.3) or LPN staffing (mean HPRD 0.9) and COVID-19.

RN Staffing

Higher RN staffing may be associated with lower resident COVID-19 infection and mortality (low confidence). Four studies investigated the relationship between RN staffing and COVID-19 cases or mortality. The 2 state-level studies and 1 regional study all found that higher RN staffing was significantly associated with fewer COVID-19 cases and/or mortality. However, 1 national study found higher RN staffing was significantly associated with higher likelihood of nursing home having any COVID-19 cases (OR 1.34, $p < 0.01$).

LPN and NA Staffing

LPN staffing may not be associated with COVID-19 infection or mortality, while NA staffing may be associated with lower infection and mortality (low confidence for both). A single national study examined the relationship between LPN or NA staffing and COVID-19 outcomes. It found no statistical association between LPN staffing and COVID-19 cases and low LPN staffing relative to medium LPN staffing was associated with fewer COVID-19 deaths. High LPN staffing relative to medium LPN staffing was not associated with COVID-19 mortality. Among nursing homes with at least 1 COVID-19 case, those with high NA staffing (compared with middle tertile) had a lower likelihood of having an outbreak and fewer COVID-19 resident and staff deaths.

Total Staffing

It is unknown if total staffing is associated with COVID-19 infections or mortality (very low confidence). One national study and 1 state-level study examined associations between total nurse staffing and COVID-19 outcomes. The national study found that nursing homes with both

low and high total staffing (compared to middle tertile) had fewer COVID-19 deaths. The state-level study found no association between nursing hours and COVID-19 cases.

Nurse Skill Mix

Higher nursing skill mix may be associated with higher resident COVID-19 infection (low confidence). The same national study described above also examined the relationship between nurse skill mix COVID-19 outcomes. Skill mix was measured as RN to total nurse staffing. This study found that lower staff skill mix was significantly associated with lower likelihood of having any COVID-19 cases, while higher skill mix was associated with greater likelihood. The study found no association between staff skill mix and COVID-19 mortality.

Other Infections

Six articles evaluated the association between nursing home staffing and infections. Four studies evaluated UTI, another study examined a composite measure of UTI, pneumonia, and pressure ulcers, and the sixth study addressed increased hospitalizations and mortality during norovirus outbreaks. Two of these were high quality and used longitudinal design, while 3 moderate-quality studies were cross-sectional and 1 moderate-quality study was also longitudinal. Two studies used an instrumental variable approach.

One study focused specifically on VA CLCs, evaluating the composite measure noted above. Three studies focused on nursing homes in a single state or a small number of states. The remaining 2 studies focused on a national sample of US nursing homes. Staffing measures were obtained from study-specific survey data, OSCAR, or VA payroll data. Outcome data were obtained from the MDS and Nursing Home Compare. Across these studies of non-VA US nursing homes, RN HPRD ranged from 0.1 to 0.6. In the VA CLC study, average total nurse staffing was 4.6 HPRD (SD 1.2), with 31% being RN, 26% LPN, and 42% NA.

RN Staffing

Higher RN staffing may be associated with fewer UTI among residents (low confidence). Three studies addressed the relationship between RN staffing and urinary tract infections. One high-quality study using an instrumental variable approach found greater RN staffing was significantly associated with lower UTI. Another instrumental variable study of moderate quality found no significant association between RN staffing and UTI. A national study of moderate quality found that higher RN staffing was significantly associated with higher rates of UTI. Lower RN staffing may also be associated with worse outcomes (hospitalizations and mortality) for nursing home residents during norovirus outbreaks.

LPN and NA Staffing

LPN and NA staffing may not be associated with UTI among nursing home residents (low confidence). One study of a national sample of nursing homes found no significant association between LPN staffing and rates of UTI, but showed that higher NA staffing was associated with lower rates.

Total Staffing

Total staffing may not be associated with UTI (low confidence). The study of VA CLCs found no significant association between total nurse HPRD and a composite measure of UTI, pneumonia, and pressure ulcers. A national study of non-VA US nursing homes categorized total nurse staffing as ≥ 5.0 HPRD or < 5.0 HPRD, with 88% being in the latter category; this study found no association between total staffing and UTI.

Nurse Skill Mix

Higher skill mix staffing may be associated with fewer UTI in nursing home residents (low confidence). Three studies investigated the relationship between nurse skill mix and infections, and there was variation in the direction of effects across the studies. One study defined skill mix as total licensed nurse FTE (RN and LPN) to total nurse staffing, finding that it was not significantly associated with UTI. One study using an instrumental variable approach found that higher skill mix (RN to total) was associated with fewer UTI. The VA CLC study examined both percent RN staffing (of total) and percent NA staffing; it found no significant associations between either and the composite outcome of UTI, pneumonia, and pressure ulcers.

Pain (Moderate-Severe)

Six moderate-quality studies examined associations between nurse staffing and moderate-severe pain in nursing home residents, all using MDS 2.0 data for outcomes. MDS 2.0 data on residents with moderate-severe pain relied on reports by nursing home staff (beginning in 2010, pain outcomes in MDS 3.0 have been assessed by resident interviews). Five studies used data for national nursing home samples, and 1 study evaluated nursing homes in 6 states (Missouri, Texas, Pennsylvania, New York, Connecticut, and New Jersey).

RN, LPN, and NA Staffing

Five studies evaluated associations between nurse staffing (measured as RN, LPN, or NA FTE per 100 residents) and rates of residents with moderate-severe pain. All 5 studies were conducted by the same lead author, and all used study-specific surveys of nursing home administrators to assess nurse staffing. Across these studies, NA FTE made up more than half of total nurse staffing, ranging from 26-33 FTE per 100 residents. RN staffing ranged from 12-15 FTE and LPN staffing was 11-17 FTE. Higher RN staffing may be associated with lower rates of moderate-severe pain among nursing home residents (low confidence). Significant results were reported by 3 studies; for example, 1 of these found 0.5% fewer residents with moderate-severe pain (per nursing home) for every 1 FTE higher RN staffing (per 100 residents). However, 2 studies did not find significant associations between RN staffing and rates of moderate-severe pain in residents.

It was unclear if LPN and NA staffing were also associated with rates of moderate-severe pain among NH residents (very low confidence for both). Two studies reported that higher LPN and NA staffing were both associated with lower rates of moderate-severe pain among long-stay patients. Two studies found no significant associations for LPN staffing, while 1 of these showed a significant association for NA staffing. The last 2 studies found inconsistent results for LPN and NA staffing for pain in long-stay and short-stay residents.

Total Staffing

It was unclear if total nurse staffing is associated with moderate-severe pain in nursing home residents (very low confidence). One study examined data for a national nursing home sample and found that total nurse staffing was not associated with the likelihood of a nursing home being in highest 75th percentile for rates of residents with moderate to severe pain. This study did not report whether long-stay or short-stay residents (or both) were included in assessment of pain outcomes.

Nurse Skill Mix

Higher skill mix may be associated with lower rates of moderate-severe pain among nursing home residents (low confidence). Four studies evaluated associations between skill mix and rates of moderate-severe pain. Three studies were conducted by the same lead author, defined skill mix as the ratio of RN FTE to total non-RN FTE (LPN and NA), and found that higher ratios were associated with lower rates of moderate-severe pain among long-stay residents. For example, 1 of these studies reported that 1% higher RN ratio was associated with 0.2% lower rates of moderate-severe pain. One of these studies also evaluated moderate-severe pain among short-stay residents but found no significant association with skill mix. Finally, 1 study found no association between skill mix (RN and LPN to total nurse staffing) and likelihood of the nursing home being in highest 75th percentile for residents with moderate-severe pain.

Urinary Catheters

Seven studies addressed the use of urinary catheters and all used MDS data for outcome data. All were moderate quality and conducted between 2000 and 2008. Five of the studies were from the same research group, Castle et al. Six of studies were cross-sectional, while the seventh used a longitudinal design. Five studies evaluated data for national samples of nursing homes, 1 looked at nursing homes only in Colorado, and the seventh examined nursing homes in 6 states (Missouri, Texas, Pennsylvania, New York, Connecticut, and New Jersey).

Results regarding nurse staffing and use of urinary catheters in nursing homes were inconsistent, with some studies finding significant associations and others finding none. All 7 studies evaluated RN staffing, with 4 showing a significant association between higher RN staffing and lower use of catheters, and the other 3 studies finding no significant associations. Four studies found a significant association between higher NA staffing and lower catheter use, and 1 study found no association. Two studies showed a significant association between higher skill mix and lower catheter use, while the third study found no association. None of the studies addressed total nurse staffing.

Functioning

Three studies addressed functioning in nursing home residents and all used MDS data on worsening in activities of daily living (ADL, including bed mobility, transfer, eating, and toileting) or basic mobility (able to move around the room). One high-quality study measured nurse staffing hours by observation and detailed self-reports from staff at 105 nursing homes in 4 states (Colorado, Indiana, Mississippi, and Minnesota), specifying resident-specific time (attributed by staff to individual residents) out of total direct care HPRD by RN, LPN, or NA. Higher resident-specific time was associated with greater likelihood of ADL decline for RN (coefficient 0.09, OR 1.09, $p < 0.05$), LPN (coefficient 0.13, OR 1.14, $p < 0.05$), and NA

(coefficient 0.42, OR 1.52, $p < 0.001$). Higher total RN HPRD was associated with lower likelihood of decline in ADL at 90 days (coefficient -0.27, OR 0.76, $p < 0.05$), but LPN HPRD was associated with higher likelihood of decline (coefficient 0.25, OR 1.28, $p < 0.05$); NA HPRD did not have a significant association (coefficient not reported). Notably, baseline data for ADL came from the MDS assessments closest to the time period during which nurse staffing hours were assessed (ADL assessments could have been before or after staffing measurement); there was also substantial variation in the gap between MDS assessment and nurse staffing measurement (mean 0.2 days, SD 24.2 days).

The 2 remaining moderate-quality studies were conducted by the same group and both examined worsening ADL and mobility. One evaluated a national sample of 2,840 nursing homes, finding that higher RN, LPN, and NA staffing were all associated with lower proportions of residents with ADL decline (coefficients -0.06 to -0.09, $p \leq 0.05$).^{6 6} For mobility, higher RN and LPN staffing were associated with lower proportion of residents with decline (coefficients -0.06 and -0.05, $p \leq 0.05$), but NA staffing was associated with higher proportion with decline (coefficient 0.27, $p \leq 0.05$). The other study examined data for 1,071 nursing homes from 6 states (Missouri, Texas, Pennsylvania, New York, Connecticut, and New Jersey), showing that higher RN staffing, modeled as log(FTE per 100 residents), was associated with lower proportions of residents with declines in ADL (coefficient 0.76, $p < 0.01$) and mobility (coefficient 0.83, $p < 0.01$). LPN and NA staffing were not significantly associated with declines in ADL or mobility.

Quality of Life

Three moderate-quality studies reported on the association between nurse staffing and quality of life; 2 examined outcomes for Minnesota nursing homes, and 1 study evaluated nursing homes in western New York. All 3 studies used in-person resident interviews to assess quality of life across broad domains. Results were inconsistent across studies, with 1 study finding that only RN HPRD was associated with quality of life, another study showing that only NA HPRD was associated with quality of life, and the third study not finding any significant associations for nurse staffing levels or skill mix.

Hospitalizations

One high-quality and 4 moderate-quality studies examined hospitalizations among nursing home residents. Three studies were longitudinal, and the remaining 2 were cross-sectional.^{8,15 8,15} Four studies evaluated national samples of nursing homes, using CMS claims data to determine hospitalizations for nursing home residents. The fifth study used state agency data on hospitalizations for nursing homes in New York. Two studies focused specifically on potentially avoidable hospitalizations (PAH) among nursing home residents before death.

Three studies evaluated effects of total nurse staffing levels, with 2 showing no associations with PAH within 90 days of death or overall hospitalization rates. The third study showed a significant association between higher total staffing and a slightly lower odds of PAH within 1 year of death (OR 0.94 [0.90, 0.99], $p = 0.02$). Two studies examined effects of RN staffing; 1 showed that higher RN staffing was associated with a small decrease in probability of 30-day readmissions, and the other did not find significant associations between RN staffing and time to first hospitalization (or time between repeat hospitalizations). Only 1 study examined LPN and NA staffing and found no associations between these staffing levels and probability of 30-day

readmission. Three studies evaluated skill mix and all 3 found an association between higher skill mix and fewer hospitalizations.

Deficiency Citations for Quality of Care

One high-quality and 4 moderate-quality studies addressed associations between nurse staffing and citations for a range of deficiencies. All studies used deficiency citations captured in OSCAR data; citations were for concerns related to resident safety or quality of care. Four studies included national samples of nursing homes, while 1 study focused on nursing homes in New York. Three studies were conducted by the same group, used national samples of nursing homes, and evaluated separate associations with RN, LPN, and NA staffing. One of these found that higher RN, LPN, and NA staffing were all associated with somewhat lower odds of having a citation (OR 0.89-0.91, $p < 0.05$ or $p < 0.001$). Another study found no associations between nurse staffing and deficiency citations (OR 0.77-1.01 for RN, LPN, and NA; $p > 0.05$ for all), while the third study showed lower likelihood of citations with higher RN staffing (OR 0.95, $p < 0.01$) but higher likelihood with higher LPN staffing (OR 1.02, $p < 0.05$), and no association with NA staffing (OR 1.01, $p > 0.05$). The fourth national study examined associations between total nurse staffing (RN, LPN, and NA; dichotomized at < 5.0 or ≥ 5.0 HPRD) and the likelihood of being in the highest 75% percentile in number of citations (out of the set of citations for quality of care), finding no significant association (OR 1.03, 95% CI [0.63, 1.69]). This study also evaluated association with skill mix, measured as proportion of licensed nurse staffing (RN and LPN) out of total nurse staffing; there was no significant association (OR 0.99, 95% CI [0.97, 1.01]). The final study evaluated associations between nurse staffing (RN, LPN, or NA) and receiving citations for quality of care for 162 nursing homes in New York. Only higher RN staffing was associated with nursing homes having lower counts of citations (coefficient -0.25, $p = 0.005$); there were no significant associations for LPN or NA staffing. This study also examined associations with likelihood of receiving more serious quality of care citations but found no significant effects for any nurse staffing variable.

Other Outcomes

Only 1-2 high- and moderate-quality studies addressed each of the following outcomes: use of antipsychotic medications, falls with major injury, discharge to home or community and all-cause mortality. Both studies examining antipsychotic medications used OSCAR and Medicaid data. One included nursing homes in Colorado, while the second study used data from a national sample of nursing homes. Both studies found no significant association between RN HPRD and antipsychotic medications. The second study found that higher LPN and NA HPRD were associated with slightly higher rates of antipsychotics use (coefficients 0.1-0.3, $p < 0.05$).

Two studies addressed resident falls. Both evaluated national samples of nursing homes, using data on nurse staffing from CASPER/OSCAR and falls data from MDS. These 2 studies found inconsistent results; 1 showed that higher RN HPRD, but not LPN or NA, was associated with a lower rates of falls. In contrast, the other study showed that higher NA HPRD, but not licensed nurses (RN and LPN), was associated with significantly fewer resident falls. Inconsistent results may have been due to different analytic decisions due to varying primary goals; 1 was mainly focused on impact of occupational and physical therapy staffing (with nurse staffing included as covariates), whereas the other study aimed to address organizational factors of nursing homes.

One study examined resident discharge to the community from 68 nursing homes who had contracted with a private company (aimed at improving outcomes for Medicare Advantage). Outcomes were assessed for residents who were at the nursing homes for 100 days or less; nursing homes with ≥ 3.5 HPRD were more likely have residents discharged to the community (OR 1.53 [1.29–1.80]).

One addressed mortality rates at 612 California nursing homes in response to new state regulations in 2000 that mandated 3.2 HPRD. Using an instrumental approach, this study found that among nursing homes which had fewer HPRD than required (pre-2000), those that increased their HPRD had fewer resident deaths (6 deaths per 1 HPRD).

DISCUSSION

Summary of Key Findings

We identified 44 eligible studies addressing processes of care and resident outcomes in nursing homes (KQ 1). We did not find any eligible studies that addressed KQ 2. All eligible studies were observational in design, with the vast majority using CMS datasets. Only 1 study focused on outcomes in VA CLCs; no studies compared outcomes across VA CLCs and non-VA community nursing homes. The most frequently addressed outcomes were pressure ulcers and nursing home-associated infections, with one-third of the latter group evaluating COVID-19. Key findings include the following:

- Higher RN staffing is probably associated with fewer pressure ulcers among residents of nursing homes (moderate confidence); LPN and NA staffing may also be associated with fewer pressure ulcers (low confidence)
- Total nurse staffing is probably not associated with pressure ulcers in residents (moderate confidence), but higher skill mix may be associated with fewer pressure ulcers (low confidence)
- Higher RN and NA staffing, and higher skill mix, may be associated with lower resident COVID-19 infection and mortality in nursing homes, while LPN staffing may not be associated with COVID-19 outcomes (low confidence for all findings)
- Higher RN staffing and skill mix may be associated with fewer UTI among nursing home residents, while LPN, NA, and total staffing may not be associated with rates of UTI (low confidence for all findings)
- Higher RN staffing and skill mix may be associated with lower rates of moderate-severe pain among nursing home residents (low confidence), but it is unclear if LPN, NA, and total staffing are associated with pain outcomes (very low confidence)
- Only 1-2 studies addressed effects of nurse staffing on use of antipsychotics medications, falls with major injury, discharge to community, and all-cause mortality
- Results for other resident outcomes and processes of care were largely inconsistent across studies, and sometimes within the same study

The use of CMS-mandated data to study nursing home outcomes is powerful and practical but presents several concerns. CMS data were not collected for research purposes, but to meet federal requirements for nursing homes. As these data directly inform payment or ability to operate, and most are reported by nursing home staff, there may be under-reporting of certain outcomes and over-reporting of staffing levels. In 2016, CMS started to require that staffing data be based on payroll (or other auditable information), but most eligible studies used CMS staffing data collected before this change. Additionally, in many studies, outcomes data were not clearly collected after nurse staffing data, which may change over time. CMS data captures nurse staffing at a certain time or averaged over some time period. This presents challenges for understanding the potential impact of fluctuations in nurse staffing (eg, over intervening weeks or differences between weekdays and weekends). Timing of CMS data collection is likely also not ideal for capturing rates of acute outcomes such as nursing home-associated infections. These methodological concerns limit the ability to detect true associations, and may contribute to counter-intuitive results, such as when insufficient nurse staffing leads to under-detection of pressure ulcers or pain among residents. Staffing assessment of patient-centered outcomes (eg, pain) may also substantially differ from resident or family reports. This concern has been addressed by changes in MDS 3.0 data collection (beginning in 2010) that now incorporate resident interviews, but none of the eligible studies examining pain used MDS 3.0 data.

Notably, studies for 2 outcomes (COVID-19 infections and quality of life) often used data sources outside of these CMS datasets. COVID-19 studies used a variety of sources including state agency data and reports from news organizations to capture COVID-19 cases and mortality. However, these studies still used CMS data on nurse staffing, which are collected once a year; although studies selected the timepoint for staffing data before the time period when COVID-19 infections occurred, these studies would not have captured any fluctuations in staffing during the early stages of the pandemic. Several studies on quality of life used in-person interviews with nursing home residents, but these were limited to data for nursing homes in a single state.

Variation across studies in analytic approaches, definitions of nurse staffing, and outcomes measures presented substantial challenges for interpretation and synthesis of results. In particular, nurse staffing measures varied for RN, LPN, or NA, and also total nurse staffing or total licensed nursing (RN and LPN). Similarly, there was different measures of skill mix, with some focusing on RN effort or time. Because these staffing measures are related and these relationships may vary depending on state-level regulations regarding specific types of nurse staffing, analytic modeling decisions likely impacted ability to detect separate effects due to RN, LPN, and NA staffing.

Some studies used instrumental variables approaches, in particular using data before and after policy changes regarding nursing home regulations (*ie*, taking advantage of a natural experiment). However, there remains substantial challenges to observational analyses of the relationship between nurse staffing and resident outcomes. Nursing homes are complex, heterogenous environments. They are regulated by multiple federal, state, and other agencies. Even high-quality observational studies may not be able to account for all resident population and facility confounders. Nurse staffing may play a key role in resident outcomes, but it is not the only factor. Other healthcare staff (*eg*, physician and non-physician providers, and allied health professionals), the physical environment, and other staff within a nursing home may also affect resident outcomes. The number of these other factors and their complex interplay were considered in conceptual models employed in multiple eligible studies. Accurate data were

generally not available for all of these confounding factors. Thus, it is difficult to distinguish causal effects of nurse staffing apart from higher nurse staffing (or skill mix) being an indicator of generally positive environments or higher resources in nursing homes.

Implications for VA Policy

We found only 1 eligible study that evaluated outcomes for VA CLCs. There are substantial concerns in generalizability of results from studies of non-VA community nursing homes to VA CLCs. VA CLC residents are likely very different from the average community nursing home resident. Federal law and VA policies require VA to treat any qualifying Veteran, regardless of ability to pay and especially if care needs reflect injuries or conditions related to past military service (*ie*, service-connected conditions). This requirement, along with being hospital-based facilities, contribute to some demographic differences, more health conditions and care needs, and overall greater acuity, compared with community nursing home residents. For example, most CLC residents are male, younger, and have higher rates of certain conditions (*eg*, PTSD). These differences may contribute to higher rates of certain outcomes in VA CLC residents. Furthermore, by VA policies, VA CLCs must have higher levels of nurse staffing (particularly RN staffing), compared to community nursing homes. For example, the single eligible study on outcomes in VA CLCs showed that the average total nurse staffing in CLCs was 4.6 HPRD, with 31% being RN staffing (*ie*, 1.4 RN HPRD for each CLC). Community nursing homes generally had much less RN HPRD. Beyond staffing levels, there are likely other important differences in the nursing workforce and work environment between VA CLCs and community nursing homes. Therefore, the results showing better resident outcomes with higher RN staffing in community nursing homes may be less applicable to VA CLCs.

Aside from these concerns regarding applicability, larger environmental factors (*eg*, nursing shortages) may present substantial challenges to increasing nurse staffing. Nursing homes may also be less desirable employers compared with other facilities (*eg*, hospitals) that also need nursing staff, due to differences in salary and benefits, or other factors in the work environment. Additionally, our results suggest very small potential differences in resident outcomes associated with nurse staffing. For example, 1 study showed that 1 FTE higher of RN staffing per 100 residents reduced the rate of moderate-severe pain in residents by 0.5%; this indicates that 2 additional FTE of RN staffing in a nursing home with 100 residents are needed to prevent 1 case of pain. Using an estimated \$75,000 for salary and benefits for RN, it would take \$150,000 to prevent 1 resident from having moderate-severe pain. VA salaries for RNs are often higher, leading to even greater costs for VA. While data are not available for cost-effectiveness calculations, higher RN staffing is also likely to reduce the costs associated with other outcomes including pressure ulcers, urinary tract infections, and COVID-19 infections.

Although outside the scope of this current review, VA CLCs may wish to consider changes beyond nurse staffing in order to improve specific resident outcomes. Other potential options include modifications to the nursing home environment and processes (*eg*, engaging all nurse staffing in care planning), and greater resources for other allied health professionals (*eg*, social workers and mental health staff). Some of these measures have been implemented by certain VA CLCs, including specialized teams to address behavioral symptoms among residents with dementia.

Research Gaps/Future Research

We identified only 1 eligible study on nurse staffing and resident outcomes in VA CLCs; this focused on a composite outcome of pressure ulcers, pneumonia, and UTI. Due to concerns noted above regarding applicability of results from non-VA community nursing homes, we recommend conducting future studies that examine other high-priority outcomes in VA CLC residents.

Additionally, dedicated assessments of nurse staffing and resident outcomes in observational studies may provide more accurate evaluations of the effects of nurse staffing. It would also be valuable to include data on organizational culture and other structural characteristics of nursing homes that are not usually reflected in CMS datasets. Although CMS has recently started to require reporting of nurse turnover and weekend nurse staffing, there remain other aspects of staffing and work environment that are likely important but not captured by CMS data.

Finally, all eligible studies used observational designs. Randomized evaluations of nurse staffing may be logistically challenging and also may engender substantial ethical concerns (*eg*, lowering nurse staffing below currently accepted levels may create unacceptable risks for resident safety). However, the complex relationships between nurse staffing, nursing home facility characteristics, and resident factors make it very difficult to understand causal effects of nurse staffing from observational studies alone. One possible avenue to address these concerns is to consider an implementation science approach and study designs that incorporate randomization in real-world setting (*eg*, stepped wedge). For example, a new initiative could offer more resources for nurse staffing to participating nursing homes, with different facilities randomly selected to increase staffing over different time periods. If such a study were conducted within a large integrated health system, such as the VA, there may be additional opportunities to use existing health information technology infrastructure to capture resident outcomes.

Limitations

This review focused on nursing home staffing, and not on other organizational or structural factors of nursing homes that may be important for resident outcomes. We also prioritized resident outcomes and processes of care based on the needs of our VA stakeholders. Because our goal was to inform current policy and decision-making within the VA, we also limited eligibility to studies of US nursing homes using data from 2000 or later. Nursing homes are governed by a complex set of national (and state) regulations, which have substantially changed since 2000 and likely very different in other countries. Training and experience for nursing staff may also vary across different countries. There may also be differences in resident characteristics, related to varying national regulations and financial policies for nursing home benefits. Therefore, our results are likely not applicable to outcomes in non-US nursing homes.

Conclusions

Evidence on nurse staffing and resident outcomes and processes of care from observational studies indicate that higher RN staffing and skill mix were associated with fewer pressure ulcers, fewer nursing home-associated infections, and lower rates of moderate-severe pain. Effects of LPN, NA, and total staffing were mixed or unclear for these outcomes. Relationships between nurse staffing and a variety of other outcomes were inconsistent, or only evaluated by 1-2 studies. These findings may not generalize to VA CLCs, which have different resident characteristics and higher staffing levels than non-VA community nursing homes. More accurate

and randomized study designs may be required to definitely evaluate the effects of nurse staffing on resident outcomes and processes of care.

ABBREVIATIONS TABLE

Abbreviation	Definition
ADL	Activities of daily living
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
CLC	Community Living Center
COE	Certainty of Evidence
CMS	Centers for Medicare and Medicaid Services
ESP	Evidence Synthesis Program
HPRD	Hours per resident day
KQ	Key question
LPN	Licensed practice/vocational nurse
MDS	Minimum Data Set
MeSH	Medical subject heading
NA	Nursing assistant
NH	Nursing home
NHC	Nursing Home Compare
NORS	National Outbreak Reporting System
NR	Not reported
OR	Odds ratio
PAH	Potentially avoidable hospitalizations
RN	Registered nurse
TEP	Technical expert panel
US	United States
UTI	Urinary tract infection
VHA	Veterans Health Administration

EVIDENCE REPORT

INTRODUCTION

PURPOSE

The VA Evidence Synthesis Program (ESP) was asked by the VA Office of Nursing Services, in collaboration with Geriatrics and Extended Care, for an evidence review on the effects of nurse staffing levels and skill mix on quality of care and resident outcomes in nursing homes. Findings from this review will be used to guide the development of nurse staffing recommendations for VA nursing homes, as well as to inform VA guidance for State Veterans Homes.

BACKGROUND

In the United States (US), 1.3 million people reside in more than 15,000 nursing homes.^{2,3} Nursing homes are complex environments with heterogeneous populations needing rehabilitative post-acute, end-of-life, or custodial long-term care. Nursing home residents have diverse care needs and diagnoses that vary within and across facilities.⁴ Nursing homes may be stand-alone facilities (independently owned or part of a network of facilities) or part of integrated care networks that include hospitals and clinics or continuing care communities that include independent and assisted living units.⁵ Within nursing homes, direct care nursing staff (*ie*, registered nurses [RN], licensed vocational or practical nurses [LPN], and nursing assistants [NA]) are the primary caregivers for residents⁶; thus, the level and characteristics of nursing staff are likely to impact resident well-being, health, safety, and quality of life.

US nursing homes are governed by complex regulatory and payment policies.⁷ States license nursing homes to operate, and the Centers for Medicare and Medicaid Services (CMS) certifies facilities to receive Medicare and/or Medicaid payments. Almost all US nursing homes are CMS certified. Although the Institute of Medicine recommends that nursing homes have at least 1 RN on duty 24 hours a day,^{7,8} federal and state regulations do not currently require this level of nurse staffing.⁹ Federal regulations only require having at least 1 RN on duty 8 hours a day, and that nursing homes have sufficient staff to provide nursing care to all residents (Nursing Home Reform Act 1987).¹⁰ States can impose more stringent regulations but none currently require that nursing homes have an RN on duty 24 hours per day. State regulations typically require a specific number of nursing hours per resident per day (HPRD). For example, California currently requires a minimum of 3.5 HPRD of direct nurse staffing.^{11,12} As part of the Nursing Home Compare 5-Star Rating System, CMS calculates expected staffing levels based on resident acuity; CMS estimates that the average US nursing home should have 4.2 hours of nursing HPRD.⁶ However, most nursing homes have staffing levels below this.^{6,13} There are also large daily variations in staffing levels within certain facilities, and some evidence that facilities may increase staffing to coincide with annual inspections.¹³

The Department of Veterans Affairs (VA) operates 134 nursing homes, called Community Living Centers (CLCs), that together currently provide a total of 8,480 beds.¹ CLCs are often attached to VA medical centers or hospitals, but may also be stand-alone facilities.¹⁴ Due to VA nurse staffing requirements, CLCs have higher levels of nurse staffing than non-VA community nursing homes. CLCs serve a variety of resident populations, which may on average have higher acuity and complexity of needs than residents in most non-VA community nursing homes.¹⁵

There is also a set of State Veterans Homes that are independently run by state governments. These State Veterans Homes must meet federal and state regulations for nursing homes, but do not have to adhere to the same VA nurse staffing requirements as CLCs. VA has responsibility for certifying that State Veterans Homes meet certain standards and conducts annual surveys to make these determinations.

Although some studies have indicated that higher nurse staffing levels lead to better resident outcomes,¹⁶⁻¹⁸ it remains unclear how overall nurse staffing levels and skill mix can be optimized to achieve improvements in process of care (*eg*, limited use of antipsychotics) and resident outcomes (*eg*, decreased pressure ulcers and pain), particularly in the setting of constraints due to cost and nursing workforce availability.

We conducted a systematic review on the effects of nurse staffing levels and staff mix on processes of care and resident outcomes in nursing homes. In this report, we summarize the evidence on effects of nurse staffing levels and skill mix on a variety of outcomes, beginning with those selected as high priority: pressure ulcers, nursing home-associated infections, and pain outcomes. For these high-priority outcomes, we also provide certainty of evidence for the summary findings. We then describe results for additional outcomes, including urinary catheters, functioning, quality of life, and hospitalizations, among others. Finally, we discuss implications of these results for VA policy and recommendations for future research.

METHODS

TOPIC DEVELOPMENT

We worked with our representatives from the VA Office of Nursing Services and our Technical Expert Panel (TEP) to refine the review scope and develop the key questions (KQ). We developed a conceptual framework based on the Donabedian model for evaluating outcomes and quality of care provided by healthcare systems and facilities.¹⁹ The Donabedian model consists of 3 connected components: 1) Structure as organizational characteristics associated with the delivery of care (eg, number of nurses); 2) processes of care are what happens for the patient or resident (eg, prescribed antibiotics); and 3) outcomes measures that capture the effect of care on patient health or other metrics that are meaningful to the patient. In this review, we conceptualized that the structure of care in nursing homes includes nurse staffing levels and skill mix as important characteristics; these in turn impact processes of care (eg, use of antipsychotic medications and urinary catheters), which then impact resident outcomes (eg, nursing home-associated infections, pain severity, and quality of life) (Figure 1). We also considered that resident characteristics are likely to impact both processes of care and resident outcomes. Nurse staffing levels include care provided by different types of nursing staff (Table 1), as well as total care provided by all nursing staff. Nurse skill mix refers to the proportions or ratios between different types of nurses (eg, RN to total staffing).

Figure 1. Conceptual Framework

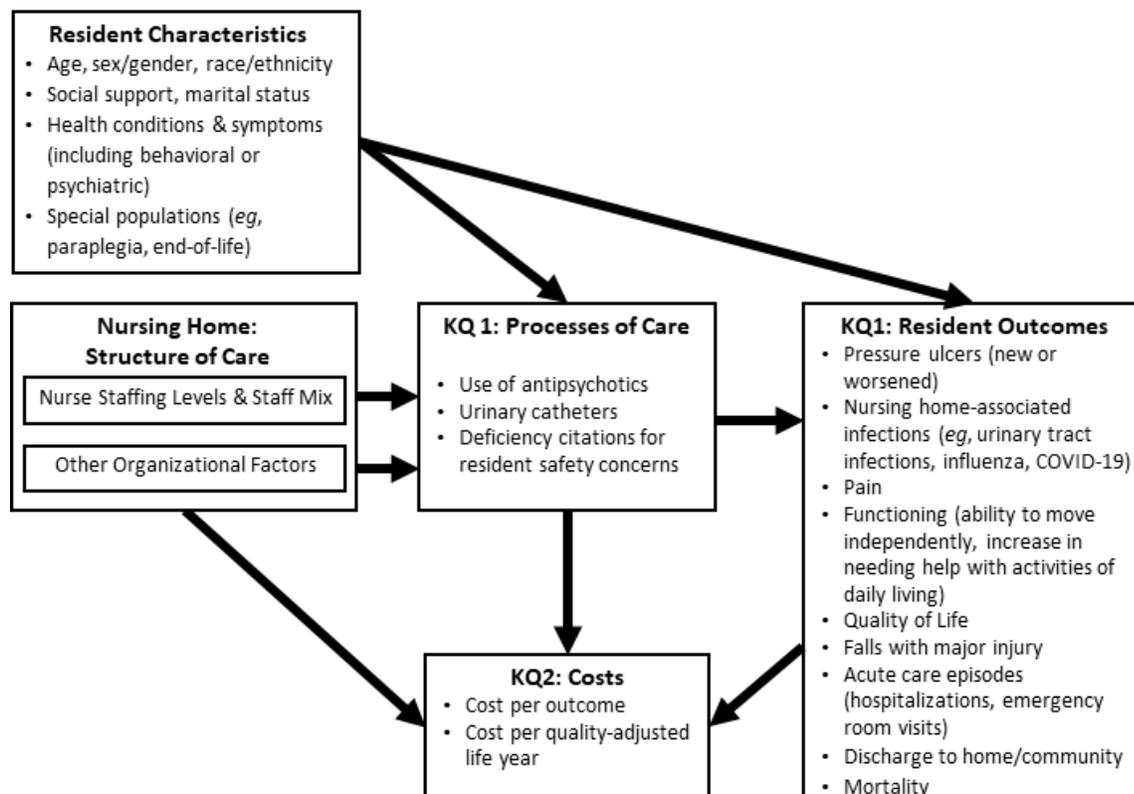


Table 1. Nursing Staff Characteristics and Responsibilities

Nursing Title	Education & Training Requirements	Responsibilities
Nursing Assistants (NA)	<ul style="list-style-type: none"> May need to complete a state-approved education program and pass their states' competency exam to become licensed or certified 	<ul style="list-style-type: none"> Provide basic care Help patients with activities of daily living
Licensed Practical or Vocational Nurses (LPN)	<ul style="list-style-type: none"> Must complete a state-approved educational program, which typically takes about 1 year Must be licensed 	<ul style="list-style-type: none"> Provide basic nursing care
Registered Nurse (RN)	<ul style="list-style-type: none"> May take different educational paths, such as bachelor's degree in nursing, or associate's degree in nursing with additional training Must be licensed 	<ul style="list-style-type: none"> Provide and coordinate patient care

*source: <https://www.bls.gov/ooh/healthcare/home.htm>

KEY QUESTIONS (KQ)

KQ1: What are the effects of nursing home nurse staffing levels and staff mix on:

- Processes of care in nursing homes (*eg*, use of antipsychotics)?
- Resident outcomes in nursing homes (*eg*, falls)?

KQ2: Which nurse staffing levels and staff mix have demonstrated cost-effectiveness for improving resident outcomes?

PROTOCOL

A preregistered protocol for this review can be found on the PROSPERO international prospective register of systematic reviews (<http://www.crd.york.ac.uk/PROSPERO/>; registration number CRD42021266319).

DATA SOURCES AND SEARCHES

We searched for peer-reviewed English-language articles from January 2000 to May 2021 in the following databases: MEDLINE, Embase, CINAHL, and the Cochrane Database of Systematic Reviews. We used Medical Subject Headings (MeSH) and title/abstract terms for nurse staffing (Table 1) and nursing homes (Appendix A). We also hand-searched bibliographies of relevant systematic reviews, identified from searches of the above databases, VA ESP, and AHRQ Evidence-based Practice Centers.

To supplement findings from the peer-reviewed literature, we also conducted a search of the grey literature. We developed a list of websites with input from our TEP and used key words to search these websites for relevant white papers pertaining to effects of nurse staffing on processes of care and resident outcomes in nursing homes. Websites searched included those for federal government agencies (*eg*, CMS, Centers for Disease Control and Prevention [CDC]), and professional organizations (*eg*, American Nurses Association); the full list of websites is provided in Appendix A. One reviewer conducted searches of websites and compiled a list of

records for potentially relevant documents; these records were then screened by another reviewer to assess relevance and possible inclusion in the review. Documents included by the second reviewer were pulled and examined by a third reviewer for final determination of inclusion.

STUDY SELECTION

After removal of duplicates and conference abstracts, citations were uploaded into DistillerSR (Evidence Partners, Ottawa, Canada). Using prespecified inclusion and exclusion criteria (Table 2), titles and abstracts were screened by 2 reviewers. Articles included by either reviewer underwent full-text review. At full-text review, 2 individuals decided on inclusion/exclusion by consensus (input from a third reviewer was requested as needed). A list of studies excluded at full-text review is provided in Appendix B.

Eligible populations were adults (≥ 18 years of age) living in US nursing homes. Studies were excluded if evaluating other types of congregate settings (eg, homes for those with developmental disabilities or transitional housing for addiction treatment). Eligible articles addressed the effects of nurse staffing levels (eg, nurse hours per patient) or skill mix (eg, ratio of RN to total nursing staff) on processes of care (eg, receipt of antipsychotics and receipt or duration of urinary catheter) and/or resident outcomes (eg, pressure ulcers, nursing home-associated infections, and pain).

Table 2. Inclusion and Exclusion Criteria

	Inclusion Criteria	Exclusion Criteria
Population	18 years or older residents of nursing homes	< 18 years of age; living in group homes for mental health or developmental disabilities, or transitional housing for addiction recovery, etc
Intervention	Staffing levels and staff mix: RN, LPN, NA (eg, nurse hours per resident, nurse to resident ratios, RN to total nurse staffing ratios)	Non-nurse disciplines
Comparator	Any	
Outcomes	<ul style="list-style-type: none"> • Process Outcomes <ul style="list-style-type: none"> – Receipt of antipsychotic, antianxiety, or hypnotic medication – Receipt and/or duration of urinary catheter – Deficiency citations for resident safety or quality of care • Resident Outcomes <ul style="list-style-type: none"> – Nursing home-associated infections (eg, urinary tract infection, influenza, pneumonia, COVID-19) – Pressure ulcers (new or worsened) – Falls with major injury – Acute care episodes (hospitalizations, emergency room visits) – Discharge to home or community 	

	<ul style="list-style-type: none"> - Functioning (ability to move independently, increase in needing help with activities of daily living) - Pain severity - Quality of life - Mortality • Cost Effectiveness <ul style="list-style-type: none"> - Cost per outcome - Cost per quality-adjusted life year 	
Timing	Any	
Setting	United States nursing homes (includes Community Living Centers and State Veterans Homes)	Assisted living facilities, facilities exclusively focused on acute care settings (<i>ie</i> , emergency rooms and inpatient floors) or congregant settings that are not providing skilled nursing services (<i>ie</i> prison, <i>etc</i>)
Study Design	Randomized controlled trials or observational studies	Reviews, study protocols, case studies, editorials, qualitative, no comparison group

DATA ABSTRACTION AND QUALITY ASSESSMENT

Study quality was independently assessed by 2 reviewers using a modified version of the Joanna Briggs Institute Critical Appraisal Tool Checklist for Analytical Cross-Sectional Studies (Appendix C).²⁰ The original tool included 8 domains: inclusion criteria, study subject and setting description, exposure measurement, identification of confounders, strategies to deal with confounders, outcome measurement, and statistical analysis. To make these criteria more applicable for longitudinal observational studies, we added 2 domains: whether the explanatory variable preceded assessment of outcomes of interest, and whether follow up was complete and adequately described. Generally, a study rated as having methodological concerns in 2 or more domains was considered low quality overall. If needed, a third reviewer also evaluated the study to help reach consensus on the quality rating. Ratings for eligible studies can be found in Appendix D.

Abstracted data from all eligible studies included the following: study design, setting and population characteristics, data sources, definitions of nurse staffing and/or skill mix, and processes of care or resident outcomes evaluated. For studies rated as moderate or high quality, we also abstracted detailed results on characteristics of staffing (amount and different types of nurse staffing, including total staffing [RN, LPN, and NA]); effects or associations between nurse staffing (or skill mix) and processes of care or resident outcomes; and detailed analytic methods (*eg*, consideration of confounders and analytic models). We categorized data sources into 5 large categories (Table 3). We also noted if study outcomes were attributed separately for VA vs non-VA facilities, or if the study primarily involved VA facilities. Data were abstracted by 1 person and over-read by second. If needed to resolve conflicts, a third reviewer also evaluated the study.

Table 3. Data Sources

Category	Data Sources
CMS	Minimum Data Set (MDS)
	Online Survey Certification and Reporting (OSCAR)
	Certification and Survey Provider Enhanced Reporting (CASPER)
	CMS National Health Safety Network Public File
	Nursing Home Compare Archives (NHC)
	Payroll Based Journal
	Provider of Service
	Medicare & Medicaid claims data
Other Federal	Medicare Healthcare Cost Report Information System (HCRIS)
	LTCFocus (https://ltcfocus.org/)
	National Nursing Home Survey (CDC)
	Census
State Agencies	Area Health Resource File
	State Agency Data
Infectious Disease	California Cost Report
	Hopkins COVID-19 Dashboard
	National Outbreak Reporting System (NORS)
Other	COVID-19 Nursing Home Dataset
	Company or corporation data
	News organizations
	American Hospital Association Database
	Surveys (independent study)
	Direct observation or time study

SYNTHESIS & CERTAINTY OF EVIDENCE

Due to heterogeneity in populations, methods, and outcomes of included studies, we performed qualitative synthesis of the results. We summarized key study findings categorized by the processes of care and/or resident outcomes being evaluated. For the 3 high-priority outcomes (pressure ulcers, nursing home-associated infections, and pain), we also rated overall certainty of evidence using a GRADE approach.²¹⁻²³ Briefly, for each outcome and nurse staffing variable, we evaluated characteristics of the evidence across 5 domains: methodological limitations, imprecision, inconsistency, indirectness, and publication bias. For methodological limitations, we considered factors such as accuracy of data assessment (for both outcomes and nurse staffing), timing of outcomes with respect to nurse staffing data, and use of appropriate analytical models. To evaluate indirectness, we examined how applicable the results were to our key questions, including population characteristics and type of outcomes assessed. For imprecision, we considered the number of events, sample size, and precision of effect estimates reported by included studies. Inconsistency relates to whether the direction and magnitude of effects are similar (or different) across the included studies. Finally, we considered the role of publication bias, which may lead to preferential reporting of positive results (particularly from small studies

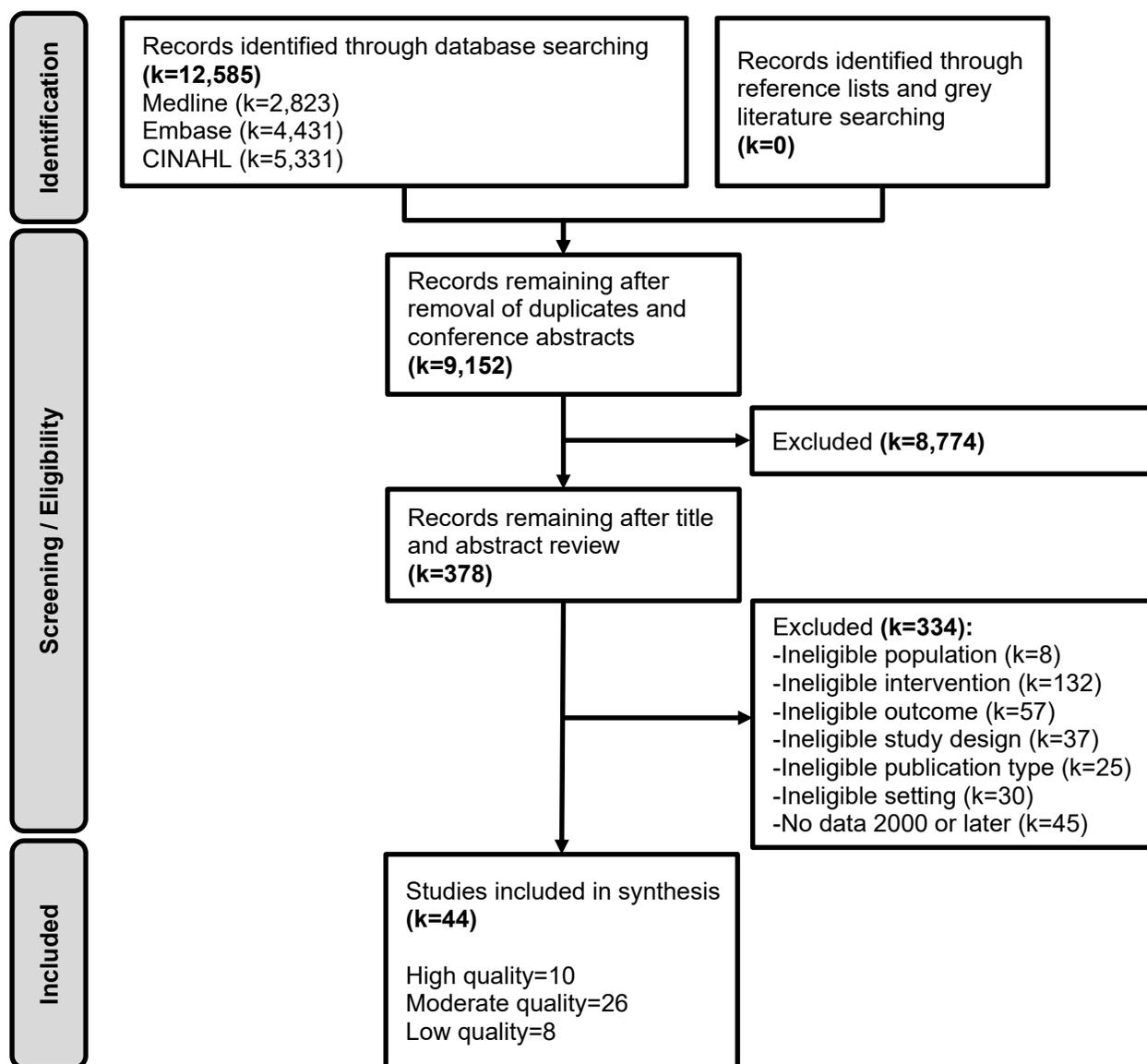
or those looking at many different outcomes). The overall certainty of evidence takes into consideration individual ratings in each of these 5 domains, but domains may not be weighted equally in determining the overall rating.

RESULTS

OVERVIEW OF ELIGIBLE STUDIES

Of 9,152 unique titles and abstracts screened, 378 articles underwent full-text review (Figure 2). We identified 44 eligible studies after full-text review. A list of studies excluded at full-text review is provided in Appendix B. We also searched 14 websites for grey literature and identified 62 documents for potential inclusion. However, none were found to be eligible after evaluation by 2 reviewers. Most of these documents did not report new data on nurse staffing or resident outcomes; the few that provided data on these topics did not conduct analyses to examine the relationship between nurse staffing and outcomes.

Figure 2. Screening and Selection of Eligible Studies



The most commonly evaluated outcomes were pressure ulcers (k=15),^{18,24-36} nursing home-associated infections (k=13),^{11,18,28,29,33,35,37-41} hospitalizations (k=8),^{24,37,42-47} residents with moderate to severe pain (k=7),^{25,26,29,31,33,35,36} and urinary catheters (k=7)^{26,28,29,31,33,35,36} (Table 4). Fourteen eligible studies addressed multiple processes of care or resident outcomes of interest.^{18,24-26,28,29,31,33-37,40,42} None of the eligible studies addressed cost effectiveness (KQ2). Most studies used national US samples of nursing homes (k=21) and were cross-sectional (k=24). Only 1 study addressed nurse staffing and resident outcomes in VA CLCs.⁴⁰ Ten included studies were high quality, 26 were moderate quality, and the remaining 8 were low quality (Table 4). Methodological concerns across many studies included: accuracy of outcomes and staffing data (most were reported by nursing home staff or administrators); timing of outcomes assessment with respect to staffing measures (*eg*, outcomes may have been assessed before data collection on staffing levels); and adequate consideration of confounders. From high- and moderate-quality studies, we abstracted detailed results on associations between nurse staffing and processes of care or resident outcomes. Detailed study characteristics and results for these studies are found in Appendix F.

First, we present results for key outcomes that were both high priority for our stakeholders and addressed by a sufficient number of studies: pressure ulcers, nursing home-associated infections, and pain (moderate to severe). We describe effects separately by different nurse staffing (*eg*, RN, LPN, or NA) or skill mix variables. We also present overall certainty of evidence for summary findings regarding these outcomes (using GRADE, see Methods). Then, we summarize results for the remaining outcomes.

Table 4. Summary Characteristics of Eligible Studies

Characteristics	# Studies by Quality		
	High (k=10)	Moderate (k=26)	Low (k=8)
Study Design			
Cross-sectional	4	16	4
Longitudinal	5	8	4
Repeated time series	1	2	—
Data Sources			
CMS	10	25	6
VA	1	—	—
Other federal sources	1	7	2
State agencies	3	14	—
Infectious disease datasets	2	1	—
Other*	4	15	3
Settings			
National US	4	15	2
State-level:			
≥10 States	2	—	—
<10 States	4	12	6
Nurse Staffing Levels & Skill Mix			

Characteristics	# Studies by Quality		
	High (k=10)	Moderate (k=26)	Low (k=8)
Nurse staffing was primary or secondary focus of study	8	13	NA
Independent variable(s):			
Nurse staffing levels	10	27	8
Skill mix	5	9	4
Resident Outcomes & Processes of Care			
Pressure ulcers	1	11	3
Infections:			
COVID-19	3	1	—
Others†	2	4	2
Pain (moderate to severe)	—	6	1
Urinary catheters	—	7	—
Functioning	1	2	2
Quality of life	—	3	1
Hospitalizations	1	4	3
Citations for quality of care	1	5	1
Antipsychotic use	—	2	—
Falls with major injury	1	1	—
Discharge to home or community	1	—	—
Mortality (all-cause)	—	1	—

Abbreviations. CMS=Centers for Medicare & Medicaid Services; NA=not abstracted; VA=Department of Veterans Affairs

*Company or corporation data, news organizations, American Hospital Association Database, independent surveys, direct observation, or time study

†Urinary tract infections, pneumonia, and norovirus

PRESSURE ULCERS

One high-quality¹⁸ and 11 moderate-quality studies^{26-33,35,36,42} evaluated the association of pressure ulcers with nurse staffing levels (see Appendix Table F-1 for detailed results). Nine studies were cross-sectional^{26,28-30,32,33,35,36,42} and 3 were longitudinal analyses.^{18,27,31} Though all 12 studies used data derived from the Minimum Data Set (MDS), the outcome measures regarding pressure sores varied across studies. Pressure ulcers were primarily measured as prevalence among NH residents, but 1 study used the incidence of pressure ulcer within the past 14 days.¹⁸ One study specifically evaluated the number of residents with dementia who died with pressure ulcers (defined as having pressure ulcers on the last MDS before death).⁴² Most studies used data from years within 1999-2008. Six evaluated national samples of nursing homes, while the remaining used data from selected states. Sample sizes ranged from 63 to 14,618 nursing homes. Besides data from federal agencies and sources, 6 studies used state agency data^{26-28,33,35,36} and 7 used other data sources (*eg*, American Hospital Association data, or private company data).^{26,30-33,35,36} Five studies were conducted by the same research team led by Castle, GC.^{26,31,33,35,36}

RN Staffing

Higher RN staffing is probably associated with fewer pressure ulcers among residents of nursing homes (moderate confidence, Table 5). Among 11 studies addressing the relationship between RN staffing and pressure ulcers, 9 found that higher RN staffing was associated with fewer pressure ulcers.^{18,26-28,31,33,35,36,42} The remaining 2 studies found no association between RN staffing levels and the outcome of interest.^{29,32} Eight studies included conceptual models to inform their study design. Six studies conducted analyses adjusting for case mix and all studies adjusted for confounders such as environment, policy, and other staffing metrics. Five studies were conducted by Castle et al and all included conceptual models.^{26,31,33,35,36} The primary methodological limitation among all studies was uncertainty about whether measures of RN staffing had preceded assessment of the pressure ulcer outcomes. The magnitude of the association between RN staffing and pressure ulcers in nursing home residents is not clear.

LPN Staffing

Higher LPN staffing may be associated with fewer pressure ulcers (low confidence, Table 5). Five moderate- and high-quality studies evaluated associations between LPN staffing and pressure ulcers.^{31-33,35,36} Four of these were from the same lead author (Castle, NG) and showed that higher LPN staffing was associated with fewer pressure ulcers.^{31,33,35,36} The fifth study found no association between measures of staffing and resident outcomes.³²

NA Staffing

Higher NA staffing may be associated with fewer pressure ulcers (low confidence, Table 5). Seven studies examined associations between NA staffing and pressure ulcers.^{26,27,31-33,35,36} Four of these found that higher NA staffing was associated with a decrease in pressure ulcer presence.^{26,27,31,36} The remaining 3 studies found no association between NA staffing levels and the outcome of interest.^{32,33,35}

Total Staffing

Total staffing is probably not associated with pressure ulcers in nursing home residents (moderate confidence, Table 5). Two studies of moderate quality evaluated total staffing and pressure ulcers in residents.^{29,30} One study was conducted in 162 facilities among high-risk patients,³⁰ while the second study had a population size of 1,142 and was among all residents.²⁹ The study by Temkin-Greener et al³⁰ had a conceptual model and controlled for case/resident mix and other confounders of interest. It found no association between total staffing and the likelihood of pressure ulcers in the resident population (OR 1.11, p=0.62). The study by Trinkoff et al²⁹ did not have a conceptual model and while it did control for other factors it did not control for case mix. As with Temkin-Greener et al, Trinkoff et al also did not find an association between total staffing and the presence of pressure ulcers (OR 1.01 [0.56, 1.82] among high-risk residents, OR 1.21 [0.58, 2.53] among low-risk residents).

Nurse Skill Mix

Higher skill mix may be associated with fewer pressure ulcers among residents (low confidence, Table 5). Six studies evaluated skill mix as ratio of RN staffing to total staffing.^{18,26,29,31,36,42} Three of the studies included a conceptual model to inform their study and analytic design. Four of the studies included case mix as a confounder of interest, and all included other confounders

such as environment, policy, and other staffing metrics in the models investigating the relationship between staff/skill mix and the outcome of interest. Three studies reported no association,^{18,29,42} and the other half of the studies reported an association between nurse skill mix and pressure ulcers.^{26,31,36}

Table 5. Summary Findings for Pressure Ulcers in Nursing Home (NH) Residents

Staffing Measure or Skill Mix	Summary of Findings	Methodological Limitations	Indirectness	Imprecision	Inconsistency	Publication Bias	Overall Confidence
RN Staffing 18,26-29,31-33,35,36,42	Higher RN staffing is probably associated with less pressure ulcers (rates or likelihood) among NH residents	Serious ^a	Not Serious	Not serious	Not Serious ^b	Not Suspected	Moderate
LPN Staffing 31-33,45,46	Higher LPN staffing may be associated with less pressure ulcers (rates or likelihood) among NH residents	Serious ^a	Not Serious	Not serious	Serious ^c	Not Suspected	Low
NA Staffing 26,27,31-33,35,36	Higher NA staffing may be associated with less pressure ulcers (rates or likelihood) among NH residents	Serious ^a	Not Serious	Not serious	Serious ^d	Not Suspected	Low
Total Staffing ^{29,30}	Total staffing is probably not associated with pressure ulcers among NH residents	Serious ^a	Not Serious	Not serious	Not Serious	Not Suspected	Moderate
Skill Mix 18,26,29,31,36,42	Higher skill mix may be associated with less pressure ulcers (rates or likelihood) among NH residents	Serious ^a	Not Serious	Not serious	Serious ^e	Not Suspected	Low

Abbreviations. LPN = Licensed Practical Nurse; NA = Nursing Assistant; RN = Registered Nurse

^a Pressure ulcers data relied on report by NH staff; most studies were cross-sectional; half or most of the results from studies conducted by the same lead author

^b Nine of 11 studies found an association between RN staffing levels and a reduction in pressure ulcers among residents

^c Four of the 5 studies were from the same lead author and all found an association; the 1 study not by the same author group found no association

^d Three studies reported no association and the remaining 4 reported an association.

^e Three studies reported no association and 3 reported an association



NURSING HOME-ASSOCIATED INFECTIONS

Ten moderate- and high-quality studies examined nursing home associated infections.^{11,18,28,29,35,39-41,48,49} We first present results for COVID-19 outcomes, followed by other infections (eg, urinary tract infection [UTI]). See Appendix Table F-1 and Appendix Table F-2 for detailed study characteristics and results.

COVID-19 Cases and Mortality

Three high-quality studies^{11,48,49} and 1 moderate-quality study³⁹ evaluated the association between nurse staffing and COVID-19 cases and/or mortality. One study evaluated combined resident and staff COVID-19 deaths.⁴⁹ Three studies were cross-sectional^{11,39,49} and 1 used repeated time series analyses.⁴⁸ Two studies evaluated nursing homes within a single state,^{11,39} while 1 study looked at nursing homes in 17 states,⁴⁸ and the fourth looked at national data.⁴⁹ All 4 studies obtained staffing data from the CMS Payroll-Based Journal (PBJ), and controlled for the facility size.^{11,39,48,49} Three of these studies also accounted for the prevalence of COVID-19 in the local community.^{39,48,49} COVID-19 data were obtained from a variety of federal,^{48,49} state,^{11,39} county,¹¹ and news organization sources.^{11,39} Methodological concerns for all of these studies were mainly regarding accuracy of data for COVID-19 outcomes reporting, timing of nursing home staffing data versus COVID-19 outcomes, and possible staff shortages due to COVID-19 outbreaks.

Across the 4 studies, RN HPRD ranged from 0.449 to 0.75. Total staffing was evaluated in 2 studies, with mean HPRD 3.9 in one,¹¹ and 55% of nursing homes < 4.1 total nurse HPRD in the other.^{11,49} Only 1 study examined relationships between NA staffing (mean HPRD 2.3) or LPN staffing (mean HPRD 0.9) and COVID-19.⁴⁹

RN Staffing

Higher RN staffing may be associated with lower resident COVID-19 infection and mortality (low confidence, Table 6). Four studies investigated the relationship between RN staffing and COVID-19 cases or mortality.^{11,39,48,49} The 2 state-level studies and 1 regional study all found that higher RN staffing was significantly associated with fewer COVID-19 cases and/or mortality.^{11,39,48} However, 1 national study found higher RN staffing was significantly associated with higher likelihood of nursing home having any COVID-19 cases (OR 1.34, $p < 0.01$).⁴⁹

LPN Staffing

LPN staffing may not be associated with COVID-19 infection or mortality (low confidence, Table 6). A single national study examined the relationship between LPN staffing and COVID-19 outcomes.⁴⁹ It found no statistical association between LPN staffing and COVID-19 cases and low LPN staffing relative to medium LPN staffing was associated with fewer COVID-19 deaths. High LPN staffing relative to medium LPN staffing was not associated with COVID-19 mortality.

NA Staffing

Higher NA staffing may be associated with lower COVID-19 infection and mortality (low confidence, Table 6). The same national study described above also examined the relationship between NA staffing and COVID-19 outcomes.⁴⁹ It found that among nursing homes with at

least 1 COVID-19 case, those with high NA staffing (compared with middle tertile) had a lower likelihood of having an outbreak and fewer COVID-19 resident and staff deaths.

Total Staffing

It is unknown if total staffing is associated with COVID-19 infections or mortality (very low confidence, Table 6). One national study⁴⁹ and 1 state-level study¹¹ examined associations between total nurse staffing and COVID-19 outcomes. The national study found that nursing home with both low and high total staffing (compared to middle tertile) had fewer COVID-19 deaths. The state-level study found no association between nursing hours and COVID-19 cases.

Nurse Skill Mix

Higher nursing skill mix may be associated with higher resident COVID-19 infection (low confidence, Table 6). The same national study described above also examined the relationship between nurse skill mix COVID-19 outcomes.⁴⁹ Skill mix was measured as RN to total nurse staffing. This study found that lower staff skill mix was significantly associated with lower likelihood of having any COVID-19 cases, while higher skill mix was associated with greater likelihood. The study found no association between staff skill mix and COVID-19 mortality.

Other Infections

Six articles evaluated the association between nursing home staffing and infections.^{18,28,29,35,40,41} Four studies evaluated UTI,^{18,28,29,35} another study examined a composite measure of UTI, pneumonia, and pressure ulcers,⁴⁰ and the sixth study addressed increased hospitalizations and mortality during norovirus outbreaks.⁴¹ Two of these were high quality and used longitudinal design,^{18,40} while 3 moderate-quality studies were cross-sectional^{28,29,35} and 1 moderate-quality study was also longitudinal.⁴¹ Two studies used an instrumental variable approach.^{18,28} One of these used the time a nursing home implemented the Medicare Prospective Payment System and percent of residents in a nursing home with Medicare as a payer source as the instrumental variables.¹⁸ The other study used the percent of the population over age 65 and the percent of females in the workforce as instrumental variables.²⁸

One study focused specifically on VA CLCs, evaluating the composite measure noted above.⁴⁰ Three studies focused on nursing homes in a single state²⁸ or a small number of states.^{18,41} The remaining 2 studies focused on a national sample of US nursing homes.^{29,35} Staffing measures were obtained from study-specific survey data,^{29,35} OSCAR,^{18,28} or VA payroll data.⁴⁰ Outcome data were obtained from the MDS,^{18,28,29,40,41} and Nursing Home Compare.³⁵ Across these studies of non-VA US nursing homes, RN HPRD ranged from 0.1 to 0.6. In the VA CLC study, average total nurse staffing was 4.6 HPRD (SD 1.2), with 31% being RN, 26% LPN, and 42% NA.⁴⁰

RN Staffing

Higher RN staffing may be associated with less UTI (proportion and likelihood) among residents (low confidence, Table 6). Three studies addressed the relationship between RN staffing and urinary tract infections.^{18,28,35} One high-quality study using instrumental variable approach found greater RN staffing was significantly associated with lower UTI.¹⁸ Another instrumental variable study of moderate quality found no significant association between RN staffing and UTI.²⁸ A national study of moderate quality found that higher RN staffing was significantly associated

with higher rates of UTI.³⁵ Lower RN staffing may also be associated with worse outcomes (hospitalizations and mortality) for nursing home residents during norovirus outbreaks.⁴¹

LPN Staffing

LPN staffing may not be associated with UTI among nursing home residents (low confidence, Table 6). One study of national sample of nursing homes found no significant association between LPN staffing and rates of UTI.³⁵

NA Staffing Level

Higher NA staffing may be associated with less UTI in residents (low confidence, Table 6). One national study of moderate quality found higher NA staffing was significantly associated with a decrease in the percent of residents with UTI.³⁵

Total Staffing

Total staffing may not be associated with UTI (low confidence, Table 6). The study of VA CLCs found no significant association between total nurse HPRD and a composite measure of UTI, pneumonia, and pressure ulcers.⁴⁰ A national study of non-VA US nursing homes categorized total nurse staffing as ≥ 5.0 HPRD or < 5.0 HPRD, with 88% being in the latter category.²⁹ This study found no association between total staffing and UTI.

Nurse Skill Mix

Higher skill mix staffing may be associated with fewer UTI in nursing home residents (low confidence, Table 6). Three studies investigated the relationship between nurse skill mix and infections, and there was variation in the direction of effects across the studies.^{18,29,40} One study of national sample of nursing homes defined skill mix as total licensed nurse FTE (RN and LPN) to total nurse staffing, finding that it was not significantly associated with UTI.²⁹ One study examining nursing homes from multiple states and using an instrumental variable approach found that higher skill mix (RN to total) was associated with fewer UTI.¹⁸ The VA CLC study examined both percent RN staffing (of total) and percent NA staffing; it found no significant associations between either and the composite outcome of UTI, pneumonia, and pressure ulcers.⁴⁰

Table 6. Summary Findings for Nursing Home (NH) Associated Infections

Staffing Measure or Skill Mix	Summary of Findings	Methodological Limitations	Indirectness	Imprecision	Inconsistency	Publication Bias	Overall Confidence
COVID-19 Cases and Mortality							
RN Staffing ^{11,3,9,48,49}	Higher RN staffing may be associated with lower COVID infection and mortality (likelihood and rates).	Serious ^a	Not Serious	Serious, borderline ^b	Serious ^c	Not Suspected	Low
LPN Staffing ⁴⁹	Higher LPN staffing may not be associated with lower resident COVID infection (likelihood) and mortality (count).	Serious ^a	Not Serious	Not Serious	—	Not Suspected	Low
NA Staffing ⁴⁹	Higher NA staffing may be associated with lower resident COVID infection (likelihood) and mortality (count).	Serious ^a	Not Serious	Not Serious	—	Not Suspected	Low
Total Staffing ^{11,4,9}	It is unknown if total staffing is associated with resident COVID infection or mortality.	Serious ^a	Not Serious	Serious, borderline ^b	Serious ^d	Not Suspected	Very Low
Skill Mix ⁴⁹	Higher nursing skill mix may be associated with higher resident COVID infection (likelihood).	Serious ^a	Not Serious	Not Serious	—	Not Suspected	Low
Other Infections							
RN ^{18,28,35}	Higher RN staffing may be associated with less UTI (likelihood and rates) among NH residents.	Serious ^e	Not Serious	Not Serious	Serious, borderline ^f	Not Suspected	Low
LPN ³⁵	LPN staffing may not be associated with rates of UTI among NH residents.	Serious ^e	Not Serious	Not serious	—	Not Suspected	Low
NA ^{29,35}	Higher NA staffing may be associated with fewer UTI among NH residents.	Serious ^e	Not Serious	Not serious	—	Not Suspected	Low
Total Staffing ⁵⁰	Total staffing may not be associated with UTI (rates and likelihood).	Serious ^e	Not Serious, borderline ^g	Not serious	Not Serious	Not Suspected	Low
Skill Mix ^{18,29,40}	Higher nursing skill mix may be associated with fewer UTI among NH residents.	Serious ^e	Not Serious, borderline ^g	Not serious	Serious, borderline ^h	Not Suspected	Low

Abbreviations. LPN=Licensed practical nurse; NA=Nursing assistant; RN=Registered nurse UTI=urinary tract infection.

^a Concerns due to accuracy of COVID-19 data, timing of nursing home staffing data vs COVID-19 outcomes, and possible staff shortages due to COVID-19 outbreaks.



^b Wide confidence intervals for some effect estimates.

^c Three studies found significant associations, while 1 study found opposite effect (higher RN staffing was associated with higher likelihood of COVID-19).

^d One study found no significant associations and the other study showed that both low and high total staffing (compared with middle tertile) were associated with higher COVID-19 mortality.

^e Cross-sectional studies with outcomes reported by NH staff.

^f Two studies showed significant associations, and 1 did not find significant association.

^g One study used composite outcome of UTI, pneumonia, and pressure ulcers.

^h Variable definitions of skill mix, with 1 study finding significant association and 2 studies not finding significant associations.

PAIN (MODERATE-SEVERE)

Six moderate-quality studies examined associations between nurse staffing and moderate-severe pain in nursing home residents, all using MDS 2.0 data for outcomes.^{26,29,31,33,35,36} MDS 2.0 data on residents with moderate-severe pain relied on reports by nursing home staff (beginning in 2010, pain outcomes in MDS 3.0 have been assessed by resident interviews). Five studies used data for national nursing home samples,^{26,29,31,35,36} and 1 study evaluated nursing homes in 6 states (Missouri, Texas, Pennsylvania, New York, Connecticut, and New Jersey).³³ Summary of findings with certainty of evidence are shown in Table 7. See Appendix Table F-3 for detailed study characteristics and results.

RN, LPN, and NA Staffing

Five studies evaluated associations between nurse staffing (measured as RN, LPN, or NA FTE per 100 residents) and rates of residents with moderate-severe pain.^{26,31,33,35,36} All 5 studies were conducted by the same lead author, and all used study-specific surveys of nursing home administrators to assess nurse staffing. Across these studies, NA FTE made up more than half of total nurse staffing, ranging from 26-33 FTE per 100 residents. RN staffing ranged from 12-15 FTE and LPN staffing was 11-17 FTE.

Higher RN staffing may be associated with lower rates of moderate-severe pain among nursing home residents (low confidence). Significant results were reported by 3 studies^{31,35,36}; for example, 1 of these found 0.5% less residents with moderate-severe pain (per nursing home) for every 1 FTE higher RN staffing (per 100 residents).³¹ However, 2 studies did not find significant associations between RN staffing and rates of moderate-severe pain in residents.^{26,33}

It was unclear if LPN and NA staffing were also associated with rates of moderate-severe pain among residents (very low confidence for both). Two studies reported that higher LPN and NA staffing were both associated with lower rates of moderate-severe pain among long-stay patients.^{26,31} One study found that higher LPN and NA FTE (per 100 residents) were each associated with higher rates of moderate-severe pain in long-stay residents but lower rates in short-stay residents.³⁵ One study found no significant associations for either LPN or NA staffing.³³ One study reported that higher NA FTE was associated with lower rates of moderate-severe pain in both long-stay and short-stay residents.³⁶ This same study reported that LPN staffing had no significant association with moderate-severe pain in long-stay residents but did have significant associations with lower rates in short-stay residents.³⁶

Total Staffing

It was unclear if total nurse staffing is associated with moderate-severe pain in nursing home residents (very low confidence). One study examined data for a national nursing home sample to evaluate association between total nurse staffing (RN, LPN, and NA; dichotomized at $<$ or \geq 5.0 HPRD) and likelihood of NH being in the highest 75th percentile for rates of residents with moderate to severe pain.²⁹ The main variables of interest were NA and licensed nurse (RN and LPN) turnover rates, analyzed in separate models. In both models, total staffing was not significantly associated with the nursing home being in the top quartile for highest rates of residents with moderate to severe pain. This study did not report whether long-stay or short-stay residents (or both) were included in assessment of pain outcomes.

Nurse Skill Mix

Higher skill mix may be associated with lower rates of moderate-severe pain among nursing home residents (low confidence). Four studies evaluated associations between skill mix and rates of moderate-severe pain.^{26,29,31,36} Three studies were conducted by the same lead author, defined skill mix as the ratio of RN FTE to total non-RN FTE (LPN and NA), and found that higher ratios were associated with lower rates of moderate-severe pain among long-stay residents.^{26,31,36} For example, 1 of these studies reported that 1% higher RN ratio was associated with 0.2% lower rates of moderate-severe pain.³¹ One of these studies also evaluated moderate-severe pain among short-stay residents but found no significant association with skill mix.³⁶ Finally, 1 study evaluated association between skill mix and likelihood of the nursing home being in highest 75th percentile for residents with moderate-severe pain.²⁹ This study measured skill mix as a ratio of total licensed nurse staffing (RN and LPN) to total direct care staffing (RN, LPN, and NA), and reported no significant association.²⁹

Table 7. Summary Findings for Pain (Moderate to Severe) in Nursing Home Residents

Staffing Measure or Skill Mix	Summary of Findings	Methodological Limitations	Indirectness	Imprecision	Inconsistency	Publication Bias	Overall Confidence
RN Staffing ^{26,31,33,35,36}	Higher RN staffing may be associated with lower rates of moderate-severe pain among NH residents	Serious ^a	Not serious	Not serious	Not serious, borderline ^b	Not Suspected	Low
LPN Staffing ^{26,31,33,35,36}	Unknown if LPN staffing is associated with rates of moderate-severe pain among NH residents.	Serious ^a	Not serious	Not serious	Serious ^c	Not Suspected	Very Low
NA Staffing ^{26,31,33,35,36}	Unknown if NA staffing is associated with rates of moderate-severe pain among NH residents	Serious ^a	Not serious	Not serious	Serious ^d	Not Suspected	Very Low
Total Staffing ²⁹	Unknown if total staffing is associated with rates in moderate-severe pain among NH residents.	Serious ^a	Not serious	Not serious, borderline ^e	—	Not Suspected	Very Low
Skill Mix ^{26,29,31,36}	Higher nursing skill mix may be associated with lower rates of moderate-severe pain among NH residents	Serious ^a	Not serious	Not serious	Not serious, borderline ^b	Not Suspected	Low

Abbreviations. LPN=Licensed practical nurse; NA=Nursing assistant; RN=Registered nurse

^a Pain outcomes reported by NH staff; most cross-sectional studies; all or most results from studies conducted by same lead author

^b No significant association in 2 studies

^c Association with lower rates in 2 studies, no significant association in 1 study, significant association only with lower rates for short-stay residents in 1 study, and both higher and lower rates (for long and short-stay patient outcomes, respectively) in 1 study.

^d Association with lower rates in 3 studies, no significant association in 1 study, and both higher and lower rates (for long and short-stay patient outcomes, respectively) in 1 study.

^e Wide confidence intervals

URINARY CATHETERS

Seven studies addressed the use of urinary catheters and all used MDS data for outcome data (see Appendix Table F-1 for detailed results).^{26,28,29,31,33,35,36} All were moderate quality and conducted between 2000 and 2008. Five of the studies were from the same research group, Castle et al.^{26,31,33,35,36} Six of the studies were cross-sectional, while the seventh used a longitudinal design.³¹ Five studies evaluated data for national samples of nursing homes,^{26,29,31,35,36} 1 looked at nursing homes only in Colorado,²⁸ and the seventh examined nursing homes in 6 states (Missouri, Texas, Pennsylvania, New York, Connecticut, and New Jersey).³³

There is inconsistency in the relationship between nurse staffing and use of urinary catheters in nursing homes, with some studies finding significant associations and others finding none. All 7 addressed RN staffing levels, 5 evaluated LPN and NA staffing levels,^{26,31,33,35,36} and 3 examined skill mix.^{26,29,31} None of the studies addressed total nurse staffing. Four studies showed a significant association between higher RN staffing and lower use of catheters,^{26,29,31,33} while the other 3 studies found no significant associations.^{28,35,36} Four studies found a significant association between higher NA staffing and lower catheter use,^{26,31,35,36} and 1 study found no association.³³ Two studies showed a significant association between higher skill mix and lower catheter use,^{26,31} while the third study found no association.²⁹

FUNCTIONING

Three studies addressed functioning in nursing home residents and all used MDS data on worsening in activities of daily living (ADL, including bed mobility, transfer, eating, and toileting) or basic mobility (able to move around the room).^{33,35,51} See Appendix Table F-3 for detailed results. One high-quality study measured nurse staffing hours by observation and detailed self-reports from staff at 105 nursing homes in 4 states (Colorado, Indiana, Mississippi, and Minnesota), specifying resident-specific time (attributed by staff to individual residents) out of total direct care HPRD by RN, LPN, or NA.⁵¹ Higher total RN HPRD was associated with lower likelihood of decline in ADL at 90 days (coefficient -0.27, OR 0.76, $p < 0.05$), but LPN HPRD was associated with higher likelihood of decline (coefficient 0.25, OR 1.28, $p < 0.05$); NA HPRD did not have significant association (coefficient not reported). Higher resident-specific time was associated with greater likelihood of ADL decline for RN (coefficient 0.09, OR 1.09, $p < 0.05$), LPN (coefficient 0.13, OR 1.14, $p < 0.05$), and NA (coefficient 0.42, OR 1.52, $p < 0.001$). Notably, baseline data for ADL came from the MDS assessments closest to the time period during which nurse staffing hours were assessed; there was substantial variation in the gap between MDS assessment and nurse staffing measurement (mean 0.2 days, SD 24.2 days).

The 2 remaining moderate-quality studies were conducted by the same group and both examined worsening ADL and mobility.^{33,35} One study evaluated a national sample of 2,840 nursing homes, finding that higher RN, LPN, and NA staffing were all associated with lower proportions of residents with ADL decline (coefficients -0.06 to -0.09, $p \leq 0.05$).³⁵ For mobility, higher RN and LPN staffing were associated with lower proportion of residents with decline (coefficients -0.06 and -0.05, $p \leq 0.05$), but NA staffing was associated with higher proportion with decline (coefficient 0.27, $p \leq 0.05$). The other study examined data for 1,071 nursing homes from 6 states (Missouri, Texas, Pennsylvania, New York, Connecticut, and New Jersey), showing that higher RN staffing, modeled as log(FTE per 100 residents), was associated with lower proportions of residents with declines in ADL (coefficient 0.76, $p < 0.01$) and mobility (coefficient 0.83,

$p < 0.01$).³³ LPN and NA staffing were not significantly associated with declines in ADL or mobility.

QUALITY OF LIFE

Three moderate-quality studies reported on the association between nurse staffing and quality of life (see Appendix Table F-4 for detailed results).⁵²⁻⁵⁴ Two studies both examined outcomes for Minnesota nursing homes, using the Minnesota Department of Human Services data on nurse staffing and in-person interviews with a random sample of residents to assess quality of life.^{52,54} These state-wide interviews used a validated multi-domain instrument to measure resident quality of life and satisfaction with care.^{52,54} One study found that higher RN HPRD was associated with higher summary quality-of-life scores, but LPN and NA HPRD were not associated with differences in quality of life.⁵² The other study found that higher NA HPRD was associated with higher composite quality of life scores, but RN and LPN HPRD were not associated with these scores.⁵⁴ Both studies adjusted for resident case mix.^{52,54}

The third study evaluated outcomes for a small number of nursing homes in western New York State.⁵³ This study used OSCAR data on nurse staffing and interviewed residents to assess quality of life; nurse staffing levels and skill mix were not associated with summary scores for quality of life.⁵³

HOSPITALIZATIONS

One high-quality⁴⁶ and 4 moderate-quality studies^{42-44,47} evaluated hospitalizations (see Appendix Table F-5 for detailed results). Three studies were longitudinal,^{44,46,47} and the remaining 2 were cross-sectional.^{42,43} Four studies evaluated national samples of nursing homes, using CMS claims data to determine hospitalizations for nursing home residents.^{42-44,47} The fifth study used state agency data on hospitalizations for nursing homes in New York.⁴⁶ Two studies focused specifically on potentially avoidable hospitalizations (PAH) among nursing home residents before death (within 90 days⁴² or within 1 year⁴⁴).

Three studies evaluated effects of total nurse staffing levels, with 2 showing no associations with PAH within 90 days of death⁴² or overall hospitalization rates.⁴⁷ The third study showed a significant association between higher total staffing and a slightly lower odds of PAH within 1 year of death (OR 0.94 [0.90, 0.99], $p = 0.02$).⁴⁴ Two studies examined effects of RN staffing; 1 showed that higher RN staffing was associated with a small decrease in probability of 30-day readmissions,⁴³ and the other did not find significant associations between RN staffing and time to first hospitalization (or time between repeat hospitalizations).⁴⁶ Only 1 study examined LPN and NA staffing and found no associations between these staffing levels and probability of 30-day readmission.⁴³ Three studies evaluated skill mix and all 3 found an association between higher skill mix and fewer hospitalizations.^{42,44,47}

DEFICIENCY CITATIONS FOR QUALITY OF CARE

Five studies addressed associations between nurse staffing and citations for a range of deficiencies (see Appendix Table F-6 for detailed results). In all studies, deficiency citations were assessed using OSCAR data. Four studies included national samples of nursing homes,⁵⁵⁻⁵⁸ while 1 study focused on nursing homes in New York.⁵⁹ One was high quality,⁵⁷ and the remaining 4 were moderate quality.^{55,56,58,59} Three studies were conducted by the same group,

used national samples of nursing homes, and evaluated separate associations with RN, LPN, and NA staffing.⁵⁵⁻⁵⁷ One of these examined odds of nursing homes having a specific citation for infection control and hand hygiene, finding that higher RN, LPN, and NA staffing were all associated with somewhat lower odds of having a citation (OR 0.89-0.91, $p < 0.05$ or $p < 0.001$).⁵⁶ The other 2 studies examined counts of⁵⁵ or odds of having any citation⁵⁷ out of a number of different citations on quality of care. One of these found no association with nurse staffing (OR 0.77-1.01 for RN, LPN, and NA; $p > 0.05$ for all),⁵⁵ and the other found lower likelihood of citations with higher RN staffing (OR 0.95, $p < 0.01$) but higher likelihood with higher LPN staffing (OR 1.02, $p < 0.05$), and no association with NA staffing (OR 1.01, $p > 0.05$).⁵⁷

The fourth national study examined associations between total nurse staffing (RN, LPN, and NA; dichotomized at < 5.0 or ≥ 5.0 HPRD) and the likelihood of being in the highest 75% percentile in number of citations (out of the set of citations for quality of care), finding no significant association (OR 1.03, 95% CI [0.63, 1.69]).⁵⁸ This study also evaluated association with skill mix, measured as proportion of licensed nurse staffing (RN and LPN) out of total nurse staffing; there was no significant association (OR 0.99, 95% CI [0.97, 1.01]).

The final study evaluated associations between nurse staffing (RN, LPN, or NA) and receiving citations for quality of care for 162 nursing homes in New York.⁵⁹ Only higher RN staffing was associated with nursing homes having lower counts of citations (coefficient -0.25, $p = 0.005$); there were no significant associations for LPN or NA staffing. This study also examined associations with likelihood of receiving more serious quality of care citations, but found no significant effects for any nurse staffing variable.

OTHER OUTCOMES

Only 1-2 high- and moderate-quality studies addressed each of the following outcomes: use of antipsychotic medications,^{28,60} falls with major injury,^{61,62} discharge to home or community,⁶³ and all-cause mortality.⁶⁴ See Appendix Table F-7 for detailed results regarding these outcomes.

Antipsychotic Use

Two eligible studies reported on associations between nurse staffing and antipsychotic medications use in nursing homes.^{28,60} Both were rated moderate quality and used OSCAR and Medicaid data. One study was cross-sectional and examined nursing homes in Colorado.²⁸ This study used least squares regression modeling and found there was no significant association between RN HPRD and antipsychotic drug use.²⁸ The second study was a repeated time series analysis using data from a national sample of nursing homes.⁶⁰ Using mixed effects linear models, this study found no significant association between RN HPRD and antipsychotic medications.⁶⁰ This study did find that higher LPN and NA HPRD were associated with slightly higher rates of antipsychotics use (coefficients 0.1-0.3, $p < 0.05$).⁶⁰

Falls with Major Injury

One high-quality⁶² and 1 moderate-quality study⁶¹ evaluated the association between nurse staffing and resident falls. The high-quality study was cross-sectional and the moderate-quality study used a repeated time series design. Both studies evaluated national samples of nursing homes, and used data on nurse staffing from CASPER/OSCAR and falls outcomes from Nursing Home Compare (NHC) or MDS.^{61,62} These 2 studies found inconsistent results regarding nurse

staffing and residents experiencing falls. Livingstone et al⁶¹ found that higher RN HPRD, but not LPN or NA, was associated with a statistically significant lower proportion of nursing home residents that had a fall. In contrast, Leland⁶² found higher NA HPRD, but not licensed nurses (RN and LPN), was associated with significantly lower resident falls. Neither study evaluated associations between nurse skill mix and resident falls. Inconsistent results between these 2 studies may have been due to their different primary goals; 1 was focused on evaluating the relationship between occupational and physical therapy staffing and resident outcomes (with nurse staffing included as covariates),⁶¹ whereas the other aimed to address organizational factors of nursing homes that included nurse staffing.⁶²

Discharge to Home or Community

One high-quality study reported on the association between nurse staffing and discharge to the community.⁶³ This study evaluated 68 nursing homes who had contracted with a private company (SeniorMetrix) that assists facilities with quality improvement for their residents with Medicare Advantage. This cross-sectional study only evaluated outcomes for residents who had lengths of stay that were 100 days or shorter and used discharge data from the private company. Total nurse staffing was dichotomized at < 3.5 HPRD (34% of nursing homes) or ≥ 3.5 HPRD (66%). This study reported that residents in nursing homes with ≥ 3.5 HPRD were more likely to be discharged to the community (OR 1.53 [1.29–1.80]).

Mortality

One moderate-quality study evaluated the association between nurse staffing and rates of nursing home residents who died.⁶⁴ This longitudinal study examined 612 California nursing homes who had less total nurse staffing than was mandated by new state regulations in 2000 (3.2 HPRD). Using an instrumental approach based on the difference between actual nurse staffing (during years before the mandate) and 3.2, this study showed that higher total nursing per HPRD was associated with 6 fewer resident deaths.⁶⁴

DISCUSSION

SUMMARY OF KEY FINDINGS

In this review, we identified 44 eligible studies that addressed the effects of nurse staffing on processes of care and resident outcomes in nursing homes (KQ 1). We did not find any eligible studies that addressed KQ 2. All eligible studies were observational in design, and the vast majority used CMS datasets to assess processes of care or resident outcomes. Only 1 study focused on outcomes in VA CLCs; no studies compared outcomes across VA CLCs and non-VA community nursing homes. The most frequently addressed outcomes were pressure ulcers and nursing home-associated infections, with one-third of the latter group evaluating COVID-19. We evaluated overall certainty of evidence for 3 high-priority resident outcomes: pressure ulcers, infections, and moderate-severe pain in residents. Key findings include the following:

- Higher RN staffing is probably associated with fewer pressure ulcers among residents of nursing homes (moderate confidence); LPN and NA staffing may also be associated with fewer pressure ulcers (low confidence)
- Total nurse staffing is probably not associated with pressure ulcers in residents (moderate confidence), but higher skill mix may be associated with fewer pressure ulcers (low confidence)
- Higher RN and NA staffing, and higher skill mix may be associated with lower resident COVID-19 infection and mortality in nursing homes, while LPN staffing may not be associated with COVID-19 outcomes (low confidence for all findings)
- Higher RN staffing and skill mix may be associated with less UTI among nursing home residents, while LPN, NA, and total staffing may not be associated with rates of UTI (low confidence for all findings)
- Higher RN staffing and skill mix may be associated with lower rates of moderate-severe pain among nursing home residents (low confidence), but it is unclear if LPN, NA, and total staffing are associated with pain outcomes (very low confidence)
- Only 1-2 studies addressed effects of nurse staffing on use of antipsychotics medications, falls with major injury, discharge to community, and all-cause mortality
- Results for other resident outcomes and processes of care were largely inconsistent across studies, and sometimes within the same study

Since our initial search, another observational study evaluating COVID-19 outcomes in nursing homes was published; total nurse staffing and skill mix (RN and LPN to total staffing) were not associated with COVID-19 rates or mortality during June-September 2020.⁶⁵ This study used CMS mandated data on COVID-19 infections for a national sample of nursing homes. Overall, results from this study did not substantially change our findings for COVID-19.

Nursing home administrators must determine the optimal nurse staffing that is financially feasible and maximizes resident outcomes. Resources needed to employ sufficient nursing staff

must be balanced against needs in other areas, such as environmental safety and recreational services. We have found only observational studies that examined the relationship between nurse staffing and processes of care and resident outcomes. The use of CMS mandated data to study nursing home outcomes is powerful and practical, but presents several concerns. CMS data (*eg*, OSCAR/CASPER and MDS) were not collected for research purposes, but to meet federal requirements for nursing homes. As these data directly inform payment or ability to operate, and most are reported by nursing home staff, there may be under-reporting of certain outcomes and over-reporting of staffing levels. In 2016, CMS switched to PBJ for nurse staffing, which required that staffing data is based on payroll (or other auditable information).⁶⁶ However, most eligible studies used CMS staffing data collected before implementation of PBJ. Additionally, in many studies, outcomes data were not clearly collected after nurse staffing data, which may also change over time. CMS data captures nurse staffing at a certain time or averaged over some time period. This presents challenges for understanding the potential impact of fluctuations in nurse staffing (*eg*, over intervening weeks or differences between weekdays and weekends). Timing of data collection is likely also not ideal for capturing rates of acute outcomes such as nursing home-associated infections. These methodological concerns limit the ability to detect true associations, and may contribute to counter-intuitive results, such as when insufficient nurse staffing leads to under-detection of pressure ulcers or pain among residents. Staffing assessment of patient-centered outcomes (*eg*, pain) may also substantially differ from resident or family reports. This concern has been addressed by changes in MDS 3.0 data collection (beginning in 2010) that now incorporate resident interviews, but none of the eligible studies examining these outcomes used MDS 3.0 data.

Notably, studies for 2 outcomes (COVID-19 infections and quality of life) often used data sources outside of these CMS datasets. COVID-19 studies used a variety of sources including state agency data and reports from news organizations to capture COVID-19 cases and mortality. However, these studies still used CMS data on nurse staffing, which are collected once a year; although studies selected the timepoint for staffing data before the time period when COVID-19 infections occurred, these studies would not have captured any fluctuations in staffing during the early stages of the pandemic. Several studies on quality of life used in-person interviews with nursing home residents, but these were limited to data for nursing homes in a single state.

Finally, variation across studies in analytic approaches, definitions of nurse staffing, and outcomes measures presented substantial challenges for interpretation and synthesis of results. Nurse staffing measures included separate effort or hours for RN, LPN, or NA, and also total nurse staffing or total licensed nursing (RN and LPN). Similarly, there was different measures of skill mix, with some focusing on RN effort or time. Because these staffing measures are related and these relationships may vary depending on state-level regulations regarding specific types of nurse staffing, the analytic approaches likely impacted whether individual studies may be able to detect separate effects due to RN, LPN, and NA staffing. Studies used a variety of analytic approaches, included mixed effects models and instrumental variables approaches. In particular, some studies evaluated data before and after policy changes regarding nursing home regulations, taking advantage of a natural experiment to evaluate the causal relationship between nurse staffing and resident outcomes. Past reviews of how nurse staffing affects resident outcomes have noted similar challenges in summarizing and interpreting the evidence from such observational studies; these have generally found mixed results across studies for a variety of outcomes with some limited evidence for better outcomes with higher staffing.⁶⁷⁻⁶⁹

There remain substantial challenges to observational analyses of the relationship between nurse staffing and resident outcomes. Nursing homes are complex, heterogeneous environments. They are regulated by multiple federal, state, and other agencies. Even high-quality observational studies may not be able to account for all resident population and facility confounders. Nurse staffing may play a key role in resident outcomes, but they are not the only factor. Other providers (eg, physicians, physician extenders, and allied health professionals), the physical environment, and policies within a nursing home also affect resident outcomes. The number of these other factors and the complexity of how they interplay was detailed in conceptual models employed in multiple eligible studies. Data were generally not available for all of these confounding factors or often had substantial limitations in accuracy. Thus, it is generally difficult to separate causal effects of nurse staffing versus higher nurse staffing (or skill mix) as an indicator of generally positive environments or higher resources in nursing homes.

IMPLICATIONS FOR VA POLICY

This review summarizes the evidence regarding the effects of nurse staffing on resident outcomes and processes of care. We found only 1 eligible study that evaluated these effects for VA CLCs. There are substantial concerns in generalizability of results from studies of non-VA US nursing homes to VA CLCs. VA CLC residents are likely very different from the average community nursing home resident. Federal law and VA policies require VA to treat any qualifying Veteran, regardless of ability to pay and especially if care needs reflect injuries or conditions related to past military service (*ie*, service-connected conditions). This requirement, along with being hospital-based facilities, likely lead to VA CLC residents having demographic differences, more health conditions and care needs, and overall greater acuity, compared with community nursing home residents.⁷⁰ For example, most CLC residents are male, are younger, and have higher rates of certain conditions (*eg*, PTSD),^{71,72} compared with majority women and lower rates of mental health concerns in community nursing home residents. These differences may contribute to higher rates of certain outcomes (*eg*, pressure ulcers) in VA CLC residents.⁷⁰ Furthermore, by VA policies, VA CLCs must have higher levels of nurse staffing (particularly RN staffing), compared to community nursing homes. For example, the single eligible study on VA CLCs showed that the average total nurse staffing was 4.6 HPRD, with 31% being RN staffing; this would be an average of 1.4 RN HPRD for each CLC. Community nursing homes generally had much less RN HPRD. Beyond staffing levels, there are likely other important differences in the nursing workforce and work environment between VA CLCs and community nursing homes. Therefore, the results regarding improved resident outcomes with higher RN staffing in community nursing homes may be less applicable to VA CLCs.

Aside from these concerns regarding applicability, larger environmental factors (*eg*, nursing shortages) may present substantial challenges to increasing nurse staffing. Nursing homes may also be less desirable employers compared with other facilities (*eg*, hospitals) that also need nursing staff, due to differences in salary and benefits, or other factors in the work environment. Additionally, our results suggest very small potential differences in resident outcomes associated with nurse staffing. For example, 1 study showed that 1 FTE higher of RN staffing per 100 residents reduced the rate of moderate-severe pain in residents by 0.5%³¹; this indicates that 2 additional FTE of RN staffing in a nursing home with 100 residents are needed to prevent 1 case of pain. Using a publicly available estimate of \$75,000 for salary and benefits for RN,⁷³ it would take \$150,000 to prevent 1 resident from having moderate-severe pain. VA salaries for RNs are often higher, leading to even greater costs for VA.

Although outside the scope of this current review, VA CLCs may wish to consider changes beyond nurse staffing in order to improve specific resident outcomes. Other potential options include modifications to the nursing home environment and processes (eg, engaging all nurse staffing in care planning), and greater resources for other allied health professionals (eg, social workers and mental health staff). Some of these measures have been implemented by certain VA CLCs, including specialized teams to address mental health and behavioral symptoms among residents with dementia.⁷⁴

RESEARCH GAPS/FUTURE RESEARCH

We identified only 1 eligible study on nurse staffing and resident outcomes in VA CLCs; this focused on a composite outcome of pressure ulcers, pneumonia, and UTI. To better understand relationships between nurse staffing and other outcomes in VA CLCs, we recommend conducting additional studies using VA data and relevant study-specific assessments. Due to concerns noted above regarding applicability of results from non-VA community nursing homes, future studies should directly address these relationships for other outcomes in VA CLC residents.

Additionally, dedicated assessments of nurse staffing and resident outcomes in observational studies may provide a more accurate evaluation of the effects of nurse staffing. It would also be valuable to include data on organizational culture and other structural characteristics of nursing homes that are not usually reflected in CMS datasets. Although CMS has recently started to require reporting of nurse turnover and weekend nurse staffing,⁷⁵ there remain many other aspects of staffing and work environment that are likely important for resident outcomes but not captured by CMS data.

Finally, all identified evidence regarding the effects of nurse staffing came from observational studies. Randomized trials of nurse staffing may be logistically challenging and also may engender substantial ethical concerns (eg, lowering nurse staffing below currently accepted levels may create unacceptable risks for resident safety). However, the complex relationships between nurse staffing, other nursing home facility characteristics, and resident factors make it very difficult to understand causal effects of nurse staffing from observational studies alone. One possible avenue to address these concerns may be to take an implementation science perspective, and consider whether certain study designs (eg, stepped wedge⁷⁶) may be used to incorporate randomization in real-world setting and more rigorously examine the effects of nurse staffing. For example, a new initiative could offer more resources for nurse staffing to participating nursing homes, with different facilities randomly selected to increase staffing over different time periods. If such a study were conducted within an integrated regional or national health system, such as the VA, there may be additional opportunities to leverage existing infrastructure for resident health information that would provide more timely and accurate information than CMS datasets.

LIMITATIONS

This evidence review has several limitations. The focus of this review was on nursing home staffing, and not on other organizational or structural factors of nursing homes that may be important for resident outcomes. We also limited results to resident outcomes and processes of care to those that were of interest to our stakeholders. Because our goal was to inform current policy and decision-making within the VA, we also limited eligibility to studies of US nursing

homes using data from 2000 or later. Nursing homes are governed by a complex set of national (or more local) regulations, which have substantially changed since 2000 and may be very different for other countries. Training and experience for different types of nursing staff may also vary across different countries. There may also be differences in resident characteristics of non-US nursing homes, related to regulations and financial policies for nursing home benefits. Therefore, our results are likely not applicable to the effects of nurse staffing in non-US nursing homes.

CONCLUSIONS

Evidence on nurse staffing and resident outcomes and processes of care come from observational studies. Higher RN staffing and skill mix were associated with fewer pressure ulcers, fewer nursing home-associated infections, and lower rates of moderate-severe pain. Effects of LPN, NA, and total staffing were mixed or unclear for these outcomes. Relationships between nurse staffing and a variety of other outcomes were inconsistent, or only evaluated by 1-2 studies. These findings may not generalize to VA CLCs, which have different resident characteristics and higher staffing levels than non-VA community nursing homes. More accurate and randomized study designs may be required to definitely evaluate the effects of nurse staffing on resident outcomes and processes of care.

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APPENDIX A. SEARCH STRATEGIES

MEDLINE

1	Long term care/
2	Exp nursing homes/
3	Exp homes for the aged/
4	((senior* or continuity care or disabled or old age or geriatric* or elder care*) adj2 (lodge* or facility* or home* or residence* or centre* or center*)).mp.
5	Or/1-4
6	Nurses/or nurse administrators/ or nurse clinicians/ or nursing staff/ or licensed practical nurses/ or nursing assistants
7	workload/or shift work schedule/
8	nursing/ or nursing administration research/
9	(((((RN or staff* or care or case or nurse* or skill) adj1 mix) or (staffing adj1model* or care model*) or ((nurs* or staff* or patient* or client) adj1 ratio*) or (nursing adj1 delivery systems\$1) or (staff* adj1 level*) or (nurs* adj1 (availb* or coverage or presence or hours or role or dose or schedul* or workforce)) or (minute* or hour* or time)) adj1 (patient* or client* or resident*)).ti,ab.
10	OR/6-9
11	5 and 10
12	Limit 11 to English
13	Limit 12 to yr="2001-current"
14	Limit 12 to yr="2013 – current"

EMBASE

1	Institutional care/
2	Nursing home patient/
3	Exp nursing homes/
4	Exp homes for the aged/
5	((senior* OR continuity care OR disabled OR old age OR geriatric* OR elder care*) ADJ2 (lodge* OR facility* OR home* OR residence* OR centre* OR center*)).mp.
6	Or/1-5
7	Nurse/or nurse administrator/ or clinical nurse specialist/ or nursing staff/ or nursing assistants/
8	workload/or shift schedule/
9	((RN OR staff* OR care OR case OR nurse* OR skill) ADJ1 mix) OR (staffing ADJ1 model* OR care model*) OR ((nurs* OR staff* OR patient* OR client) ADJ1 ratio*) OR (nursing ADJ1 delivery systems\$1) OR (staff* ADJ1 level*) OR (nurs* ADJ1 (availb* OR coverage OR presence OR hours OR role OR dose)) OR (minute* OR hour* OR time) ADJ1 (patient* OR client* OR resident*)
10	OR/7-9
11	6 and 10

12	Limit 11 to English
13	Limit 12 to yr="2001-current"
14	Limit 12 to yr="2013-current"

CINAHL

1	MH "long term care"
2	MH "nursing homes"
3	TI ((senior* OR "continuity care" OR disabled OR "old age" OR geriatric* OR "elder care*") N2 (lodge* OR facility* OR home* OR residence* OR centre* OR center*))
4	AB ((senior* OR "continuity care" OR disabled OR "old age" OR geriatric* OR "elder care*") N2 (lodge* OR facility* OR home* OR residence* OR centre* OR center*))
5	S1 OR S2 OR S3 OR S4
6	(MH "Nurses") OR (MH "clinical nurse specialists") OR (MH "practical nurses") OR "nursing assistants"
7	MH "workload"
8	MH nursing administration research
9	TI ((RN OR staff* OR care OR case OR nurse* OR skill) N1 mix) OR ("staffing" N1 "model*" OR "care model*") OR ((nurs* OR staff* OR patient* OR client) N1 ratio*) OR (nursing N1 "delivery systems*1") OR (staff* N1 level*) OR (nurs* N1 (availb* OR coverage OR presence OR hours OR role OR dose)) OR (minute* OR hour* OR time) N1 (patient* OR client* OR resident*)
10	AB ((RN OR staff* OR care OR case OR nurse* OR skill) N1 mix) OR ("staffing" N1 "model*" OR "care model*") OR ((nurs* OR staff* OR patient* OR client) N1 ratio*) OR (nursing N1 "delivery systems*1") OR (staff* N1 level*) OR (nurs* N1 (availb* OR coverage OR presence OR hours OR role OR dose)) OR (minute* OR hour* OR time) N1 (patient* OR client* OR resident*)
11	S6 OR S7 OR S8 OR S9 OR S10
12	S5 AND S11
13	English (use the LA language field)
14	EM 200101- (limits to Jan 2001 to present)
15	EM 201301- (limits to Jan 2013 to present)

GREY LITERATURE

Site	Date of Access	Terms
Centers for Medicare and Medicaid services www.cms.gov	9-15-2021	"staffing levels"
Centers for Disease Control www.cdc.gov	9-15-2021	"staffing levels" as exact phrase; "nursing home, long term care, community living center" as any of these words

American Association of Retired Persons www.aarp.org	9-14-2021	"staffing levels"
American Health Care Association/National Center for Assisted Living Ahcancal.org	9-14-2021	"staffing levels" "nursing home" and filtered by content type of "AHCA Report"
Office of the Assistant Secretary for Planning and Evaluation https://aspe.hhs.gov/	9-8-2021	"nursing home" and filtered by topic of "Nursing Home and Facilities" "staffing levels" and filtered by topic of "Long-Term Services & Supports, Long-Term Care"
American Nurses Association Nursingworld.org	9-10-2021	"staffing levels"
Leading age https://www.leadingagemn.org/	9-13-2021	"nursing home"
McKnight https://www.mcknight.org/	9-10-2021	"nursing home"
Pioneer Network https://www.pioneernetwork.net/	9-10-2021	"nursing home"
Gerontological Society of America https://www.geron.org/	9-10-2021	"nursing home"
American Association of Colleges of Nursing https://www.aacnnursing.org/	9-10-2021	"nursing home"
Kaiser Family Foundation https://www.kff.org/	9-13-2021	"nursing home" and filtered by content type of "report"

APPENDIX B. EXCLUDED STUDIES

1. Nurse staffing hours is 1 of several factors that affect quality of care for nursing home residents. *AHRQ Research Activities*. 2000(243):13-13. *Ineligible study design*.
2. Staffing level mix affects quality of care in nursing homes. *AHRQ Research Activities*. 2009(343):6-7. *Ineligible publication type*.
3. Nursing homes using more agency staff have lower quality of care. *AHRQ Research Activities*. 2010(358):8-8. *Ineligible publication type*.
4. Staff shortages linked to infection citations in LTC. *Hospital Infection Control & Prevention*. 2011;38(6):68-70. *Ineligible study design*.
5. Nurse-patient ratios in aged care. *Australian nursing journal (July 1993)*. 2013;20(7):4. *Ineligible publication type*.
6. LPN Supervision In Long Term Care Facilities. *Iowa Board of Nursing Newsletter*. 2014;33(3):8-8. *Ineligible intervention*.
7. Medication Incidents Occurring in Long-Term Care. *Info Nursing*. 2014;45(3):33-35. *Ineligible setting*.
8. RESIDENTIAL AGED CARE SERVICES and the employment of nursing staff. *Nurses' Paycheck*. 2015;15(1):32-34. *Ineligible publication type*.
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19. Arnetz JE, Zhdanova LS, Elsouhag D, Lichtenberg P, Luborsky MR, Arnetz BB. Organizational climate determinants of resident safety culture in nursing homes. *The Gerontologist*. 2011;51(6):739-749. *Ineligible intervention*.
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37. Bowblis JR, Meng H, Hyer K. The urban-rural disparity in nursing home quality indicators: The case of facility-acquired contractures. *Health Services Research*. 2013;48(1):47-69. *No eligible outcomes*.
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39. Brady L. Prompted voiding yields results. CNAs are key to the success of a pilot study that reduced urinary incontinence for residents of 1 Illinois facility. *Provider (Washington, DC)*. 2009;35(3):41-44. *Ineligible intervention*.
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APPENDIX C. CRITERIA USED IN QUALITY ASSESSMENT

Question	Yes	No	Unclear
1. Is it clear in the study that the “staffing level/mix” preceded the outcome of interest?			
2. Were the criteria for inclusion in the sample clearly defined?			
3. Were the study subjects (<i>ie</i> , nursing homes) and the setting (<i>ie</i> , geography, national vs state, number of homes) described in detail?			
4. Was the exposure (staffing level/mix) measured in a valid and reliable way?			
5. Were confounding factors identified?			
6. Were strategies to deal with confounding factors stated?			
7. Were the outcomes measured in a valid and reliable way?			
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?			
9. Was the appropriate statistical analysis used?			

**If all responses are “yes” overall ROB = low, if 2 or more responses are “no” overall ROB = high, all other combinations overall ROB = moderate

APPENDIX D. QUALITY RATINGS FOR ALL ELIGIBLE STUDIES

Author	Is it clear in the study that the “staffing level/ mix” preceded the outcome of interest?	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects (ie, nursing homes) and the setting (ie, geography, national vs state, number of homes) described in detail?	Was the exposure (staffing level/mix) measured in a valid and reliable way?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Was the appropriate statistical analysis used?	Overall
Abrahamson ⁵⁴	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Alexander ²⁵	Unclear	Yes	Yes	Yes	No	No	Yes	Not applicable	Yes	Low
Arling ⁵¹	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
Bosco ³⁷	Unclear	Yes	Yes	Yes	Unclear	No	Yes	Not applicable	Yes	Low
Bostick ³⁴	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Low
Bowblis ⁶⁰	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Moderate
Castle ⁵⁵	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Castle ³¹	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Moderate
Castle ³³	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Castle ³⁶	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Castle ²⁶	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate



Author	Is it clear in the study that the “staffing level/ mix” preceded the outcome of interest?	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects (ie, nursing homes) and the setting (ie, geography, national vs state, number of homes) described in detail?	Was the exposure (staffing level/mix) measured in a valid and reliable way?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Was the appropriate statistical analysis used?	Overall
Castle ⁵⁶	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Castle ³⁵	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Castle ⁵⁷	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
Castle ³⁸	Unclear	Yes	Yes	Yes	Yes	Yes	No	Unclear	No	Low
Crawford ⁷⁷	Yes	Unclear	Unclear	Yes	Yes	No	Yes	Yes	No	Low
Domi ⁴⁸	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Flynn ³²	Unclear	Yes	Yes	Yes	Unclear	Unclear	Yes	Not applicable	Unclear	Moderate
Gorges ⁴⁹	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
Harrington ¹¹	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Hefele ⁶¹	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Konetzka ¹⁸	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
Lee ²⁸	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Leland ⁶²	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
Lerner ⁵⁸	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate

Author	Is it clear in the study that the “staffing level/ mix” preceded the outcome of interest?	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects (ie, nursing homes) and the setting (ie, geography, national vs state, number of homes) described in detail?	Was the exposure (staffing level/mix) measured in a valid and reliable way?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Was the appropriate statistical analysis used?	Overall
Li ³⁹	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Lin ²⁷	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Moderate
Ogunneye ⁴⁵	No	Yes	Unclear	Unclear	Yes	No	Yes	Unclear	No	Low
O'Malley ⁴⁶	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	High
Orth ⁴²	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	No	Moderate
Shin ⁵³	Unclear	No	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Shin ⁷⁸	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	Not applicable	Unclear	Low
Shippee ⁵²	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Moderate
Temkin-Greener ⁵⁹	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Temkin-Greener ³⁰	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear	Not applicable	Yes	Moderate
Thomas ⁴³	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Tong ⁶⁴	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Trinkoff ²⁹	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate



Author	Is it clear in the study that the “staffing level/ mix” preceded the outcome of interest?	Were the criteria for inclusion in the sample clearly defined?	Were the study subjects (ie, nursing homes) and the setting (ie, geography, national vs state, number of homes) described in detail?	Was the exposure (staffing level/mix) measured in a valid and reliable way?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the outcomes measured in a valid and reliable way?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Was the appropriate statistical analysis used?	Overall
Trivedi ⁴¹	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Uchida-Nakakoji ⁴⁰	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
Warren ⁶³	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	High
White ²⁴	Unclear	Unclear	Yes	Unclear	Yes	No	Yes	Unclear	No	Low
Xing ⁴⁴	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate
Xu ⁴⁷	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable	Yes	Moderate

APPENDIX E. PEER REVIEW DISPOSITION

Comment #	Reviewer #	Comment	Author Response
<i>Are the objectives, scope, and methods for this review clearly described?</i>			
1	1	Yes	Thank you.
2	3	Yes	Thank you.
3	4	Yes	Thank you.
4	5	Yes	Thank you.
5	6	Yes	Thank you.
6	9	Yes	Thank you.
<i>Is there any indication of bias in our synthesis of the evidence?</i>			
7	1	No	Thank you.
8	3	No	Thank you.
9	4	No	Thank you.
10	5	No	Thank you.
11	6	No	Thank you.
12	9	No	Thank you.
<i>Are there any published or unpublished studies that we may have overlooked?</i>			
13	1	No	NA
14	3	Yes - See my general comments for additional papers that should be included, and why Nurse staffing and patient outcomes: Strengths and limitations of the evidence to inform policy and practice. A review and discussion paper based on evidence reviewed for the National Institute for Health and Care Excellence Safe Staffing guideline development. P. Griffiths, J. Ball, J. Drennan, C. Dall'Ora, J. Jones, A. Maruotti, et al. Int J Nurs Stud 2016 Vol. 63 Pages 213-225 Accession Number: 27130150 DOI: 10.1016/j.ijnurstu.2016.03.012	Thank you for the suggested articles; however, none of these met our inclusion criteria. Griffiths et. al. is a review article, and not an eligible study design. Needleman et. al. and Winter et al. both addressed nurse staffing in hospitals, which was not an eligible setting for this review.

Comment #	Reviewer #	Comment	Author Response
		<p>Nurse staffing and inpatient hospital mortality. J. Needleman, P. Buerhaus, V. S. Pankratz, C. L. Leibson, S. R. Stevens and M. Harris. N Engl J Med 2011 Vol. 364 Issue 11 Pages 1037-45. Accession Number: 21410372 DOI: 10.1056/NEJMsa1001025</p> <p>Winter SG, Bartel AP, de Cordova PB, Needleman J, Schmitt SK, Stone PW, Phibbs CS. The Effect of Data Aggregation on Estimations of Nurse Staffing and Patient Outcomes. In press, Health Services Research, 2021;56(6):1262-1270. DOI: 10.1111/1475-6773.13866 PMID: 34378181</p>	
15	4	Yes - Please see below re: COVID19 papers (comment 3c) and acknowledgment of other reviews that have been done on this literature (comment 4)	We note again that published reviews are not eligible for inclusion in this systematic review. We examined the studies included by the suggested review, and did not find any additional eligible articles for our review. Several of the articles included by the other review are already included in our review. One of the articles included by the suggested review, McGarry 2021, was published after our original search date. We now refer to this article in the Discussion, and note that these results would not have changed our overall findings or conclusions.
16	5	No	NA
17	6	No	NA
18	9	No	NA
<i>Additional suggestions or comments can be provided below.</i>			
19	1	This is a systematic review of nurse staffing in nursing homes and associated outcomes using 4 databases with a structured literature search. Because nurse staffing is never randomized, the systematic review focuses on cohort studies of nurse staffing and patient outcomes including pressure ulcers (PU), nursing home infections (NHA1), hospitalizations, pain and catheters. Studies were evidence graded and have	NA

Comment #	Reviewer #	Comment	Author Response
		variable quality. The authors separate the staffing questions into RN, LPN and NA for each outcome.	
		The executive summary is fairly long (14 pages). I am not sure of the ESP standards but typically exec summaries are 1-2 pages. The detail will be appreciated by some reviewers, but not by others.	The Executive Summary in this report is consistent with length of summaries in other ESP reports. Generally, ESP Executive Summaries are more than 2 pages long. It is unclear if reviewer is perhaps thinking of ESP management ebrieffs (which are shorter, targeted communications that are prepared after the final report), or perhaps another ESP product (eg, Evidence Briefs). However, per reviewer’s concern, we have further edited the executive summary for greater brevity.
		Page 8 Line 33-34 – please check the federal VA budget for currently operational CLC beds. The number is closer to 8500.	We originally referenced a government report that described VA CLC’s in 2018. Per reviewer’s suggestion, we have now updated the number of CLC beds based on VA’s proposed FY 2022 budget (8,480).
		Page 10 Line 34 Pressure Ulcers – Is there a GRADE for this evidence? How is age of the literature accounted? Most of these analyses were related to MDS 2.0 in a time when staffing was measured by self-report (not CMS payroll journal records). The preponderance of studies by 1 group is potentially a strength (the researchers know the topic and measurement structure) and a bias (“we are hell bent on showing that RN staffing is critical and LPN staffing is...”)	In the main text, Table 5 provides the summary of results and GRADE ratings for pressure ulcers. Similarly, Table 6 describes the results and GRADE ratings for nursing home-associated infections. GRADE ratings take into account methodological limitations (including concerns regarding accuracy or bias of datasources) and overall consistency of results across studies, along with other domains (see Methods). The concern with age of the literature, if not directly related to accuracy of the data, would be considered in the Indirectness domain, which looks at whether study results are applicable and meaningful for the KQ addressed by our review.
		Page 11, NHAI – is there a GRADE for the evidence?	For consistency, we have reported p-values throughout this review with the leading zero.
		Page 12, line 23 – Do you need an extra zero in the p-value?	All 4 studies described in this section had controlled for nursing home size. Three of these also adjusted for a measure of COVID-19 prevalence in the community (eg,

Comment #	Reviewer #	Comment	Author Response
		<p>Page 12, line 18 – Was community prevalence and facility size included in these studies? Both increase the likelihood of introduction into NHs.</p>	<p>COVID-19 cases per 1,000 residents). We have added this information to the Results.</p>
		<p>Page 12, line 56 – I very much appreciate the analysis of UTI. While perhaps outside the scope, I am wondering if the studies postulated a potential mechanism. The reason for the comment is that this section may be intertwined with the Urinary Catheter analysis.</p>	<p>We appreciate reviewer’s suggestion regarding potential link between the use of urinary catheters and rates of UTI in nursing homes. However, this relationship was not examined in the 3 moderate-quality studies which addressed both UTI and urinary catheters (Trinkoff 2013, Lee 2014, and Castle 2010). Instead, urinary catheters and UTI (both assessed using MDS) were modeled as different outcomes in separate analyses. Additionally, there were several studies that examined only urinary catheters or UTI, without having the other outcome.</p>
		<p>In addition, it may be important to include dates on these studies (at least pre & post MDS 3.0), the differences in the MDS 2.0 and MDS 3.0 are important. Also there have been various initiatives over the years.</p>	<p>We note both the publication dates and the dates of data (for nurse staffing and outcomes) in Appendix tables. We agree that changes in outcomes assessment (eg, due to newer reporting processes to MDS) are important considerations and have highlighted these in the relevant Results sections and the Discussion.</p>
		<p>Page 14 Line 6 – Of the 6 studies, 5 were conducted by the same PI? Thanks for bringing it up – see comment about bias above.</p>	<p>Thank you.</p> <p>As noted above, there were several studies that addressed UTI but not urinary catheters. Only 1 of the 5 studies examining UTI were conducted by Castle et al.</p>
		<p>Page 15 line 7 – Similar comment on bias by a single PI Should this be included with NHAI – UTI? Perhaps not, but the clinical undertone of catheter use is UTI predisposition...</p>	<p>The timing of staffing and outcomes assessment was a substantial methodological limitation for many of the included studies. We have provided more information about this for the specific section indicated by reviewer, and also expanded on this in the Results overview and Discussion.</p>
		<p>Page 15 line 46 – Should there be a comment that sometimes the MDS was after the staffing measurement?</p>	

Comment #	Reviewer #	Comment	Author Response
		<p>Page 16 line 42 – were all deficiency citations included? Some deficiencies are directly related to staffing.</p>	<p>We describe in greater detail the type of deficiency citations within the main text Results and in Appendix Table F-6. Eligible studies addressing deficiency citations counted a variety of different citations, but these had to be relevant to resident safety and/or quality of care (eg, infection control or medication management). We have clarified this in the Executive Summary—Results section.</p>
		<p>For the summary of Key findings Page 18 line 9 – please make sure that all of the GRADES are included in the text of the executive summary.</p>	<p>We have ensured that all GRADE certainty of evidence ratings are included in the text of the Executive Summary in each applicable section.</p>
		<p>Page 20 line 6 – there is finally a reference for the VA CLC Population: https://www.jamda.com/article/S1525-8610(21)00910-5/fulltext</p>	<p>We have added this citation to the Discussion.</p>
		<p>Page 20 line 19-24 – Great example and important point! Page 21 line 28 – Great point about changes in NHs since 2000.</p>	<p>Thank you.</p>
		<p>Page 25 Fig 1 – I am not sure how AP meds are a ‘process’, but will allow for your conceptual diagram.</p>	<p>The prescribing and use of a medication is usually considered a process in the Donabedian model. A process of care is defined as “what is actually done in giving and receiving care” [Donabedian, JAMA 1988].</p>
		<p>Page 34 table 5 – these are really powerful tables! I know that you have referenced the methodology. Please consider giving a paragraph or footnote to defining each of the column headers</p>	<p>Thank you. The GRADE methodology for determining certainty of evidence is complex and tailored to the specific outcomes of interest. We have provided citations and greater explanation in the relevant Methods section (main text).</p>
20	3	<p>Overall, the review conducted is sound and the conclusions are supported by the evidence.</p>	<p>Thank you.</p>

Comment #	Reviewer #	Comment	Author Response
		<p>One issue that should probably be noted is that the 1 VA CLC nurse staffing study included in this review used a statistical method that, given the very high VA staffing levels, was essentially set up to not find effects for staffing levels. That study was designed to look at the effects of unit tenure on outcomes; it did find that increased RN and LPN tenure was associated with better outcomes. Since it used a fixed-effects model, the estimates for the effect of staffing (HPPD) were driven by deviations from each unit’s average staffing level. Given the very high VA CLC staffing levels (see below), modest reductions in staffing probably can’t be expected to have any effect on patient outcomes. A note to this effect should probably be added to the detailed discussion of the findings of this paper.</p>	<p>We agree that comparisons among VA CLCs would only detect impacts of nurse staffing that are relevant at high staffing levels, particularly as compared with non-VA community nursing homes. However, we do not believe that this limitation could be addressed by different statistical techniques (eg, using random effects models). In the Discussion, we have emphasized that no eligible study compared outcomes between VA and non-VA nursing homes, and that this is a substantial gap in the evidence.</p>
		<p>In the discussion, I think that more emphasis/comment needs to be made to make it very clear that the staffing in CLCs is very different from community nursing homes. There are several relevant issues.</p> <ol style="list-style-type: none"> 1. VA RN wages are set by law to match of the average of the CMS wage index, and this is dominated by the nursing salaries for RNs working in acute care. Acute care RNs receive a premium, compared to RNs who work in other settings, thus the wages that VA pays for RNs working in CLCs are above market. 2. Related, there is some evidence that at least some RNs take positions in the CLC as a stepping stone to get into the VA, and then transfer to another RN position when 1 becomes available. 3. For LPNs and Aides, the VA wage differential with the community nursing homes varies by market, but it is almost always competitive, and in some markets may be above market. 4. For all nursing staff, the VA benefit package is almost always better than the average benefit package for community nursing homes, sometimes significantly better. 	<p>We have expanded the Discussion section describing the many differences between VA CLCs and community nursing homes. We agree with reviewer that VA work environment and salary/benefits are likely more attractive for many nurses, but we did not find published references or publicly available reports that clearly describe these differences. Thus, we discuss these potential differences in work environment and other workforce factors in more general terms.</p>



Comment #	Reviewer #	Comment	Author Response
		<p>5. For LPNs and Aides, the VA offers training benefits that are, on average, significantly better than what is offered in the community; these are set to match those offered by acute care hospitals. Thus, there is a path to advance up the ladder with subsidized training that is not offered by many community nursing homes.</p> <p>6. **** All of the above contribute to VA being considered to be a top-tier employer for staff working in nursing homes. This results in MUCH lower staff turnover. The average tenure of an Aide working on a specific CLC unit in the VA is over 4 years, while in most community nursing homes it is less than a year!</p>	
		<p>Related note, on page 20 it is noted that nursing homes may be a less desirable type of employment, compared to hospitals, due to differences in salary and benefits. While this is true in general, it does not apply to the VA, given how VA wages and benefits are set.</p>	<p>As noted above, we have highlighted differences between VA CLCs and community nursing homes. This sentence addressed the situation for community nursing homes, as most eligible studies used data for community facilities.</p>
		<p>Main comment is that the discussion of the findings and limitations of the existing evidence only considers the work that has been done looking at how nurse staffing affects patient outcomes for long term care. The number of high-quality studies is limited, and there are some lessons that could potentially be learned from the work that has been done for acute medical/surgical care.</p> <p>Specifically, there is a very good summary of the limitations of the work on nurse staffing in acute care by Griffiths et al, 2016. Listed at end of this file. Many of the issues identified in that paper are also relevant to long term care.</p>	<p>The impact of nurse staffing on outcomes in acute care settings is outside the scope of this review. We agree that there are likely similar concerns regarding methodological limitations and gaps in evidence.</p>
		<p>Endogeneity and how nurse staffing is measured are key limitations of much of the literature on how nurse staffing affects patient outcomes. It was noted that many of the studies relied on surveys to determine nurse staffing levels, and this method is subject to bias. Further, with only a few</p>	<p>We agree that method of assessing nurse staffing is a major methodological concern for this body of evidence (and an important reason that there is low certainty of evidence for most outcomes). We have added the</p>



Comment #	Reviewer #	Comment	Author Response
		<p>exceptions, most of the studies of nurse staffing rely in very aggregated data to measure nurse staffing (e.g., annual data). This masks the fact that there can be considerable variation in staffing levels over time. Again, from the acute care literature, Winter et al, 2021 show that there is considerable aggregation bias. Further, Needleman et al, 2011 show that shift to shift variance in staffing affects outcomes.</p>	<p>specific issue that data on nurse staffing did not allow for examination of variation (over time) in staffing levels.</p>
		<p>Minor Comment: Page 20, middle, estimated RN salary and benefits. The estimated RN salary is FAR too low. HERC annually creates a dataset of the average VA wage costs for each type of employee. For the most recent year, the average RN costs (salary plus benefits) for an FTE was \$131,643 from MCA data and \$136,406 using FMS data. The data in the report should be updated.</p>	<p>We used an estimate for RN salary from publicly available information on salary.com; this most likely reflects community salaries. This is appropriate since most eligible studies examined outcomes in community nursing homes (and not VA CLCs). Additionally, we do not believe that these costs for VA nurses are publicly available (eg, these data are accessed via VA intranet sites). Thus, we have added a sentence that states generally that VA salaries tend to be higher. Finally, we used this example to highlight the high costs of changing nurse staffing to improve resident outcomes. Using the higher estimates for VA RN salaries would make this even more true (and not less so).</p>
		<p>All of the above should then be factored into the discussion about the needs for additional research.</p>	
		<p>Nurse staffing and patient outcomes: Strengths and limitations of the evidence to inform policy and practice. A review and discussion paper based on evidence reviewed for the National Institute for Health and Care Excellence Safe Staffing guideline development. P. Griffiths, J. Ball, J. Drennan, C. Dall'Ora, J. Jones, A. Maruotti, et al. Int J Nurs Stud 2016 Vol. 63 Pages 213-225 Accession Number: 27130150 DOI: 10.1016/j.ijnurstu.2016.03.012</p>	<p>As noted above, evidence on impact of nurse staffing on outcomes in acute care facilities is outside the scope of this review.</p>
		<p>Nurse staffing and inpatient hospital mortality. J. Needleman, P. Buerhaus, V. S. Pankratz, C. L. Leibson, S. R. Stevens and M. Harris. N Engl J Med 2011 Vol. 364 Issue 11 Pages 1037-45. Accession Number: 21410372 DOI: 10.1056/NEJMsa1001025</p>	

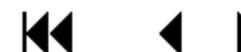
Comment #	Reviewer #	Comment	Author Response
21	4	<p data-bbox="478 264 1205 422">Winter SG, Bartel AP, de Cordova PB, Needleman J, Schmitt SK, Stone PW, Phibbs CS. The Effect of Data Aggregation on Estimations of Nurse Staffing and Patient Outcomes. In press, Health Services Research, 2021;56(6):1262-1270. DOI: 10.1111/1475-6773.13866 PMID: 34378181</p> <p data-bbox="478 427 1205 651">Thank you for the opportunity to review this synthesis of the literature assessing relationships between nursing home staffing and resident outcomes. Overall the review is well-organized, written clearly, and appears to have been conducted using robust methods. However, there are a number of issues that do need to be addressed. Please see below for specific comments.</p> <ol data-bbox="478 688 1205 1399" style="list-style-type: none"> <li data-bbox="478 688 1205 1040">1. There appears to be some miscoding of the quality assessments. In Appendix C, 1 would think that a ‘yes’ to all questions would equate with ‘high’ quality, but the note at the bottom suggests the opposite. I also see some discrepancies across tables – e.g. the Konetzka 2008 paper [ref 18] is given a rating of ‘low’ in Appendix D (even though it is regarded by most experts as 1 of the strongest papers in this literature); but then is later described as high quality in Appendix F-1. The Harrington 2020 paper [ref 10] is given a ‘low’ rating in Appendix D, but a ‘high’ rating in Appendix F-2. These are just 2 examples, but there appear to be other discrepancies. <li data-bbox="478 1078 1205 1235">2. There are several papers in Appendix D that do not appear in the Appendix F evidence tables, so were they actually included in the review of any outcomes? Among just the first few papers listed in Appendix D, I do not see Alexander, Bosco, or Bostick included anywhere in Appendix F. <li data-bbox="478 1273 1205 1399">3. The review of COVID-19 outcomes (p.11-12) needs to be expanded in three ways: <ol data-bbox="478 1338 1205 1399" style="list-style-type: none"> <li data-bbox="478 1338 1205 1399">a. First, there needs to be some separation of outcomes – I would examine probability of any outbreak, case rates, and 	<p data-bbox="1220 427 1896 456">Thank you.</p> <p data-bbox="1220 688 1896 846">These discrepancies were due to some inconsistencies in our terminology, namely that a study with high risk of bias is low overall quality and vice versa. We have corrected the appendix tables to consistently refer to “high” (or “low”) quality as appropriate.</p> <p data-bbox="1220 1078 1896 1170">As stated in the Methods, we did not undertake detailed data abstraction from low-quality studies; thus these are not included in detailed results tables (Appendix F).</p> <p data-bbox="1220 1273 1896 1399">We present summary findings by different types of nurse staffing (eg, RN or LPN) because our Technical Expert Panel recommended this as the most useful and relevant format. Detailed results for each of these studies are</p>

Comment #	Reviewer #	Comment	Author Response
		<p>mortality rates separately, as these are conceptually different from 1 another. (i.e. Better staffing is unlikely to prevent the virus from initially walking in the door, but may help to mitigate outbreaks and adverse outcomes once an incident case is identified.)</p> <p>b. Quality assessment for COVID19 studies needs to include whether the study controlled for community virus prevalence & bed size, as these have been identified as the strongest and most consistent predictors of nursing home cases & deaths. See this review: https://pubmed.ncbi.nlm.nih.gov/34549415/</p> <p>c. There are several other studies that have examined various aspects of NH staffing and COVID19 outcomes, most of which I believe were done within the timeframe of your review. See link in (3b), section on staffing, for some additional articles you probably should incorporate.</p> <p>4. There have been at least 6 reviews of the nursing home staffing-quality literature to date (listed below), and an additional review of nursing home hospitalizations that included a section on staffing (Grabowski et al, 2008). These should be mentioned somewhere in the discussion, with a comment as to how the current review adds to this existing evidence base, and how findings align or contrast with those of prior reviews. I see the Dellefield review in your reference list but couldn't find an in-text citation. I don't believe any of these others were cited.</p> <p>a. Bostick JE, Rantz MJ, Flesner MK, Riggs CJ. Systematic review of studies of staffing and quality in nursing homes. J</p>	<p>described in Appendix Table F-2. We agree that there is substantial heterogeneity in outcomes assessed by studies examining COVID-19. For example, there were not only differences in terms of counting cases, outbreaks (variably defined), and/or deaths, but also in the method for data collection (eg, CMS data vs. newspaper reports). Additionally, 2 studies were focused on data within a single state, 1 study used national data, and 1 study examined only nursing homes participating in a COVID-19 vaccination program. Therefore, there are substantial conceptual differences and concerns on multiple levels (beyond the type of outcomes included) in aggregating results across these studies. These concerns led to the "Low" and "Very Low" GRADE ratings for summary findings regarding COVID-19. Additionally, as part of quality assessment and determining the GRADE ratings, we also considered whether studies controlled for community prevalence and nursing home size. We have provided more information on these analytic factors in the Results. Please see above response to comment #15 (Reviewer 4) regarding articles included by Konetzka et al. review.</p> <p>This ESP report was conducted primarily to meet needs identified by our VA operational partners in the Office of Nursing Services, and Geriatrics and Extended Care. In our initial discussions with our VA partners, we noted there were previously published reviews, although most of these were conducted >5 years ago (the exception being the Clemens et al. review, which was not yet published at that time). For various reasons, the existing reviews did not meet the needs of our partners. As per recommended format for ESP reports, our Discussion focuses on interpretation of the evidence, including implications for VA policy and practice, and identification of evidence gaps. As systematic reviews were not</p>

Comment #	Reviewer #	Comment	Author Response
		<p>Am Med Dir Assoc. 2006;7(6):366-376.</p> <p>b. Castle NG. Nursing home caregiver staffing levels and quality of care - A literature review. <i>Journal of Applied Gerontology</i>. 2008;27(4):375-405.</p> <p>c. Dellefield ME, Castle NG, McGilton KS, Spilsbury K. The Relationship Between Registered Nurses and Nursing Home Quality: An Integrative Review (2008-2014). <i>Nursing Economics</i>. 2015;33(2):95-+.</p> <p>d. Spilsbury K, Hewitt C, Stirk L, Bowman C. The relationship between nurse staffing and quality of care in nursing homes: a systematic review. <i>Int J Nurs Stud</i>. 2011;48(6):732-750.</p> <p>e. Backhaus R, Verbeek H, van Rossum E, Capezuti E, Hamers JP. Nurse staffing impact on quality of care in nursing homes: a systematic review of longitudinal studies. <i>J Am Med Dir Assoc</i>. 2014;15(6):383-393.</p> <p>f. Clemens S, Wodchis W, McGilton K, McGrail K, McMahon M. The relationship between quality and staffing in long-term care: A systematic review of the literature 2008-2020. <i>Int J Nurs Stud</i>. 2021;122:104036.</p> <p>g. Grabowski DC, Stewart KA, Broderick SM, Coots LA. Predictors of nursing home hospitalization: a review of the literature. <i>Med Care Res Rev</i>. 2008;65(1):3-39.</p>	<p>eligible study designs for this report, we did not carefully assess and compare findings from reviews (such as those noted here). Therefore, we do not present detailed results or summaries from these reviews. We have added a more general comparison of our review with some of the previous systematic reviews. The Dellefield et al. review was cited already in the Introduction (page 25). Finally, some of these are not systematic reviews (eg, Castle 2008; Grabowski 2008) or largely included studies published >20 years ago (Bostick 2006).</p>
		<p>5. Missing from the discussion is an acknowledgment that 1 of the biggest limitations of the staffing literature to date has been the predominance of studies using OSCAR/CASPER data, which was long criticized for reporting bias since it only captured facility-reported staffing levels around the time of survey. See discussion in the Castle 2008 review (https://journals.sagepub.com/doi/10.1177/0733464808321596) about this, and Exhibit 3 in Geng et al 2019 (ref 12) for an illustration of the reporting bias. This is why CMS transitioned to the current Payroll-based Journal system in 2016.</p>	<p>We agree with reviewer that there are substantial concerns with data accuracy nurse staffing. We have clarified and highlighted these concerns in the Discussion.</p>
		<p>6. Discussion, p. 50, lines 28-31. The limitation about not measuring other organizational factors needs to be</p>	<p>As suggested by the reviewer, we have expanded this Discussion paragraph to include a reference to new CMS</p>



Comment #	Reviewer #	Comment	Author Response
		<p>expanded, particularly as it relates to other workforce factors that impact resident outcomes. Staffing levels alone are very limited measures that solely tell us on average how many people are in the building, but tell us nothing about staff retention, turnover, agency use, consistency of assignments, staff engagement, or leadership. Evidence from hospitals suggests that higher nurse staffing is only associated with better patient outcomes in hospitals where other aspects of supportive work environments are also present (e.g. https://pubmed.ncbi.nlm.nih.gov/21945978/). There is only preliminary evidence on the contribution of work environment, measured from staff surveys, to resident outcomes in nursing homes (eg. refs 22, 28, 30, 57). There have been several papers on the negative consequences of turnover in nursing homes (by Castle and others) and CMS has just announced that they will begin reporting turnover measures in NH Compare which will allow for further exploration. I would acknowledge the need to develop these areas of evidence in your section on research gaps.</p> <p>Minor</p> <p>7. Suggest adding number in-text citations throughout your results, at least when you are calling out specific studies. As is, it is difficult to tell which papers you are referencing as you summarize findings.</p> <p>8. Pg. 19, line 47 – replace ‘physician extenders’ with the more appropriate term ‘advanced practice clinicians’ or ‘advanced practice providers’</p>	<p>data collection on turnover, and the likely importance of other workforce and work environment factors. Although some of the included studies did address factors such as turnover and use of agency staff, these were not the focus of this review. Therefore, we cannot state how important these specific factors may be, particularly as compared with nurse staffing levels, or whether there are substantial evidence gaps in understanding the role of these factors.</p>
22	5	<p>Page 9, line 3 - should be “function” (not “functioning”) --- also noted in other areas of the manuscript.</p>	<p>In-text citations are included throughout the Results section of the main text. Citations are not included in the Executive Summary as this is meant to be a more concise summary of the available evidence.</p> <p>We have replaced this term with “non-physician providers”, as it is unclear whether advanced practice clinicians would include physician assistants (and other categories of non-physician providers).</p> <p>Both “function” and “functioning” have been used in the literature to describe ability to do (or difficulty with) daily tasks and participation in meaningful activities. For example, the Veterans SF-36 has a “physical functioning domain” [Kazis et al. <i>Arch Intern Med</i>, 1998] and ADLs</p>



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			have been used to assess “physical functioning” [Katz, <i>JAMA</i> , 1963].
		Page 11, line 24 - what is the definition of “total staffing”? Number of RN, LPN, and NAs combined?	We have added the definition of total staffing to Methods.
		Page 14, line 44-45 - missing “the” in “...nursing home being in THE highest 75th percentile for...”	This has been corrected.
		Page 15, line 28 - I believe this should be “Function” (not “Functioning”)... same comment for line 30	See response above.
		Page 18, line 12, Discussion - this is the first time that the KQ 1 and 2 are mentioned in the Executive Summary section. Consider introducing KQ1 and 2 earlier in the Executive Summary.	We have added the KQ to the Methods in the Executive Summary.
		Page 19, line 46 (also on page 48, line 44) - in lieu of “physician extenders”, consider using actual roles (ie, nurse practitioners, physician assistants) - see https://www.aanp.org/advocacy/advocacy-resource/position-statements/use-of-terms-such-as-mid-level-provider-and-physician-extender	This has been addressed (see response to Reviewer #4 above).
		Page 20 line 40-41 - unclear sentence, please clarify - “...VA CLCs to invest in additional avenues to improve specific resident outcomes have options.”	This sentence has been edited for clarity.
		Page 25, Figure 1 - shouldn’t there be a line from the “structure” directly to the “outcomes” as well (not just from “resident characteristics” to “outcomes”)?	The relationships between structure, processes, and outcomes are per previous descriptions of the Donabedian model (eg, Donabedian, <i>JAMA</i> 1988). In this figure, we only highlighted the processes of interest (for this review); there are clearly many other processes of care that would mediate the impact of organizational structure on resident outcomes. We have added ellipses to denote this.



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		<p>Page 26, Table 1 - RN Responsibilities column - RNs are also responsible for the application of the nursing process for each patient they care for, which includes identifying nursing diagnoses and implementation of nursing interventions that is individualized to the patient.</p>	<p>We used information from the Bureau of Labor Statistics for these general descriptions of different nurse staffing for nursing homes. We agree that there is variation in nursing practice across states, but also likely by settings (including different nursing homes).</p>
		<p>Another potential discussion point/limitation - nursing practice is governed by state nursing practice acts, which may affect processes of care and/or outcomes.</p>	
23	9	<p>Page 19 line 47 and page 48 line 44, the term physician extenders should not be used. If referring to advance practice providers (PAs, NPs, CNSs), either use the individual clinical professions, providers or the term advance practice providers.</p>	<p>This has been addressed (see response above to Reviewer #4).</p>
		<p>Page 49 and page 20, the sentence that starts on line 37 is not clear.</p>	<p>We have edited this sentence for clarity.</p>

APPENDIX F. EVIDENCE TABLES

Appendix Table F-1. Nursing Home Staffing Associations with Urinary Catheter Usage, Nursing Home-Associated Infections (non-COVID-19), and Pressure Ulcers

Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
Castle, 2015 ²⁶ ; Moderate; Cross-sectional; 3,939 free-standing NH (≥30 beds) national sample	OSCAR (2008); FTE per 100 residents (not including agency staff), mean (SD): RN 11.7 (9.3), LPN 14.6 (8.4), NA 30.4 (9.5) Skill mix—RN/(LPN+NA), mean (SD): 0.25 (0.4) % FTE filled by agency staff, mean (SD): RN 9.7% (3.3), LPN 11.2% (3.5), NA 12.1% (4.2)	NH Compare, AHRF, Survey (2008); Negative binominal regression models were used, case mix adjusted	Association between staffing and percent of residents with pressure ulcers (IRR [95% CI]) NA staffing level 0.93* [0.81, 0.97] LPN staffing level 0.83 [0.77, 1.01] RN staffing level 0.97* [0.91, 0.99] Staff mix 0.98** [0.88, 0.99] *p < 0.5 ** p < 0.01	NR	Association between staffing and percent of residents with urinary catheter left in (IRR [95% CI]) NA staffing level 0.94* [0.86, 0.99] LPN staffing level 0.88 [0.79, 1.01] RN staffing level 0.98* [0.83, 0.99] Staff mix 0.96* [0.81, 0.99] *p < 0.5
Castle, 2011 ³¹ ; Moderate; Longitudinal; 2,839 free-standing NH (≥30 beds) national sample	OSCAR (2003 – 2007); FTE per 100 residents (not including agency staff), mean (SD): RN 11.7 (9.3), LPN 14.6 (8.4), NA 30.4 (9.5) Skill mix—RN/(LPN+NA), mean (SD): 0.25 (0.4)	NH Compare, Survey (2003 – 2007); Negative binominal regression models were used.	Association between change in staffing and percent of low-risk residents with pressure sores (β (SE)): higher NA staffing levels -0.81* (0.11) higher LPN staffing levels -0.16* (0.04) higher RN staffing levels -0.46* (0.17)	NR	Association between change in staffing and percent of residents with a urinary catheter (β (SE)): higher NA staffing levels -0.36 (0.48) higher LPN staffing levels -0.49 (0.68) higher RN staffing levels -0.44* (0.06)

Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
	% FTE filled by agency staff, mean (SD): RN 9.7% (3.3), LPN 11.2% (3.5), NA 12.1% (4.2)		higher staff mix -0.42*** (0.21) *p< .001, ** p<.05		higher staff mix -0.03** (0.01) *p< .001, ** p< .01
Castle, 2007 ³³ ; Moderate; Cross-sectional; 1,071 free-standing NH (≥30 beds) national sample	OSCAR (March – June 2003); FTE per 100 residents (not including agency staff), mean (SD): RN 14.7 (9.3), LPN 16.6 (8.1), NA 33.4 (10.1) % FTE filled by agency staff, mean (SD): RN 7.7% (12.7), LPN 1.9% (3.9), NA 20.2% (18.9)	NH Compare, AHRF, Survey (2003 – 2005); Negative binomial regression models, coefficients (SE), *significant at 5%; **significant at 1%	Association between staffing characteristics and pressure sores for low and high risk residents: <u>Low Risk Residents</u> Log RN Staffing 0.939 (0.101) Log LPN Staffing 1.137** (0.055) Log NA Staffing 1.076 (0.173) <u>High Risk Residents</u> Log RN Staffing 0.808** (0.045) Log LPN Staffing 0.919 (0.111) Log NA Staffing 1.099 (0.084)	NR	Association between staffing characteristics and insertion of urinary catheter that was left in: Log RN Staffing 0.769** (0.058) Log LPN Staffing 0.991 (0.061) Log NA Staffing 1.066 (0.155)
Castle, 2010 ³⁵ ; Moderate; Cross-sectional;	NHA survey (2005); FTE per 100 residents (not including agency staff), mean (SD): RN 12.2 (8.2), LPN 12.5 (6.5), NA 25.8 (7.0)	NH Compare (2005); SEM path analysis, only coefficients with p≤0.5 were reported (otherwise NR), case mix adjusted	SEM path coefficients for % of residents with pressure ulcer: <u>RN staffing</u> Long-stay (high risk) NR Long-stay (low risk) -0.10 Short-stay -0.05	SEM path coefficients for % residents with UTI: RN staffing 0.05 LPN staffing NR NA staffing -0.03 RN agency NR	SEM path coefficients for % of residents with urinary catheter left in: NA staffing 0.04 LPN staffing NR RN staffing NR LPN agency -0.07



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
2,840 free-standing NH (≥30 beds) national sample	Agency staff FTE per 100 beds, mean (SD): RN 1.6 (1.2), LPN 2.9 (1.9), NA 6.9 (3.4)		<p><u>LPN staffing</u> Long-stay (high risk) NR Long-stay (low risk) -0.07 Short-stay NR</p> <p><u>NA staffing</u> Long-stay (high risk) -0.02 Long-stay (low risk) -0.04 Short-stay -0.07</p> <p><u>RN agency</u> Long-stay (high risk) NR Long-stay (low risk) NR Short-stay NR</p> <p><u>LPN agency</u> Long-stay (high risk) -0.12 Long-stay (low risk) 0.05 Short-stay NR</p> <p><u>NA staffing</u> Long-stay (high risk) 0.65 Long-stay (low risk) 0.56 Short-stay 0.33</p>	<p>LPN agency -0.07 NA agency 0.11</p> <p>Unstandardized structural equation model coefficients for staffing represent the percent change in urinary tract infection per a 1% change in the staffing measure.</p>	<p>RN agency NR NA agency 0.23</p>
Castle, 2008 ³⁶ ; Moderate; Cross-sectional;	OSCAR (2004); NA, LPN, and RN FTE per 100 residents. mean (SD): RN 11.7 (9.5), LPN 15.6 (8.6), NA 31.4 (9.9)	MDS, NH compare, AHRF, Survey (2004); Negative binominal regression models, coefficients (SE),	<p>Association between staffing measures and pressure ulcers among low and high risk populations:</p> <p><u>Low Risk Population</u></p>	NR	<p>Associations between staffing and urinary catheters left in:</p> <p>Log NA staffing 0.913^{***}(0.030)</p>



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
6,005 free-standing NH (≥30 beds) national sample	Skill mix—RN/(LPN+NA), mean (SD): 0.25 (0.4) % FTE filled by agency staff, mean (SD): RN 8.7% (3.1), LPN 10.2% (3.4), NA 11.1% (4.6)	*p <.05, **p < .01, ***p < .001	Log NA staffing 0.932***(0.024) Log LPN staffing 0.944 (0.042) Log RN staffing 0.836* (0.082) Log staff mix 0.836* (0.086) <u>High Risk Population</u> Log NA staffing 0.940***(0.017) Log LPN staffing 0.856***(0.043) Log RN staffing 0.878**(0.051) Log staff mix 0.878** (0.053)		Log LPN staffing 0.925** (0.033) Log RN staffing 0.960 (0.063) Log staff mix 1.060 (0.061)
Flynn, 2010 ³² ; Moderate; Cross-sectional; 63 NH in New Jersey	NHC (2006); Mean minutes of care per resident day, mean (SD): RN 51 (29), LPN 43 (26), NA 135 (29), total nurse staffing 93 (44)	NHC (2006); Linear regression models for percentage of residents with pressure ulcers	<i>“There were no significant associations between any of these metrics of nurse staffing levels and other study variables.”</i> (coefficients and other statistics NR)	NR	NR
Konetzka, 2008 ¹⁸ ; High;	OSCAR (1997 – 2000); RN HPRD, Skill mix measured as RN staffing hours as a proportion of total (RN, LPN & NA) staffing hours. Mean (SD)	MDS, Medicare Cost Reports (1997 – 2000); Logistic mixed model including an	Risk of stage 2+ Pressure Sores in past 14 days (β (SE), (p value)). Facility Fixed Effects Model:	Resident Urinary Tract Infection Fixed Effects Model Coefficient (SE) RN HRPD: 0.194 (0.106; p<0.10)	NR



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
Longitudinal; 1,366 NH (399,206 residents)	RN HPRD: 0.350 (0.291) Skill Mix: 0.117 (0.064) Instrumental variables: Indicator for when a facility implemented Medicare a Prospective Payment System and percent of residents in a nursing home with Medicare payer source in the baseline year (1997)	instrumental variable using the introduction of the Prospective Payment System (PPS) for Medicare payment in nursing homes, case mix adjusted	RN HPRD (0.123) -0.222 Skill Mix (0.424) 0.632 Instrumental Variable, Medicare PPS Model: RN HPRD (0.515) -3.006* Skill Mix (0.254) -0.0009 Instrumental Variable PPS w/residuals: RN HPRD (0.515) -3.002* Skill Mix (0.437) 0.045 *p<0.01	Skill Mix: -0.504 (0.352;p=NR) Two-stage least squares Coefficient (SE) RN HRPD: -1.528 (0.410; p<0.001) Skill Mix: -1.634 (0.525;p<0.0-1) Two-stage residual inclusion Coefficient (SE) RN HRPD: -1.556 (0.411; p<0.001) Skill Mix: -1.662 (0.495;p<0.001)	
Lee, 2014 ²⁸ ; Moderate; Cross-sectional; 195 free-standing NH in Colorado	OSCAR (2000); RN HPRD Mean (SD) [Range]: 0.6 (0.2) [0.2-1.6] Estimated RN staffing using 2 instrumental variables (percent of the population over 65 and percent of females in workforce)	MDS (2000); Ordinary least squares regression model for rates outcomes among NH residents, also instrumental variable models (uses estimated RN staffing), case mix adjusted, coefficients (SE)	Association between estimated RN staffing and pressure ulcers in low-risk residents, β (SE), (p value) $\beta = -11.272$ (SE=5.026), (p<0.05)	Percent of Residents with Urinary Tract Infection 2-stage least squares regression beta coefficient RN HPRD: 3.090 (SE=4.017; p-value=NR). Non-Instrumental Variables Estimate: NR	Association between RN HPRD and catheter left in, β (SE), (p value) $\beta = -0.684$ (SE=1.883), (p-value NR) *results reported as non-significant



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
Lin, 2014 ²⁷ ; Moderate; Longitudinal; 3,275 NH national sample	OSCAR (1999 and 2003); Includes full-time, part-time, and contract nurses Mean (SD) RN: 0.338 (0.316) NA: 2.438 (0.589) LN: 1.101 (0.550) LPN: 0.759 (0.399)	AHRF, Census (1999 and 2003); Two stage model with an instrumental variable predicting the change in nurse staffing after a policy change with required staffing levels was included in the model	Association between predicted change in staffing after policy change and the fraction of residents with pressure ulcers (β (SE)) Distance RN 0.041** (0.021) Distance NA 0.0007 (0.006) * P value < .10, **P value < .05, ***P value < .01	NR	NR
Orth, 2021 ⁴² ; Moderate; Cross-sectional; 14,618 NH national sample (191,435 residents with dementia who died in 2017)	Nursing Home Compare (2018) and LTCfocus; HPRD, mean (SD): total 3.8 (0.7) Skill mix—RN/total staffing, mean (SD): 0.16 (0.07)	MDS (2018); Mixed-effects logistic models for odds of resident with pressure ulcers at time of death, case mix adjusted and stratified analyses for severity of dementia, OR (95% CI), p-values	Total staffing hours per day (10-min increments) and pressure ulcers at time of death, stratified by dementia severity: mild: 1.00 (0.98, 1.01), p=0.50 moderate: 1.00 (0.99, 1.01), p= 0.50 severe: 0.99 (0.98, 1.01), p=0.07 Skill mix and pressure ulcers at time of death, stratified by dementia severity: mild: 0.98 (0.85, 1.12), p=0.75	NR	NR



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
			moderate: 0.93 (0.85, 1.02), p=0.12 severe: 0.91 (0.82, 1.00), p= 0.048		
Temkin-Greener, 2012 ³⁰ ; Moderate; Cross-sectional; 162 NH in New York (20,929 residents with stays ≥90 days and impaired with bed mobility or transfer, comatose or malnourished)	Survey, study specific (2006-2007); HPRD, mean (SD): RN 0.6 (0.2), LPN 0.8 (0.3), NA 2.3 (0.4), total staffing NR	MDS (2006 – 2007); Generalized estimating equations were used after risk-adjusted outcomes were identified, case mix adjusted	Association of nurse staffing (HPRD) with pressure ulcers, (OR (p value)). Total staffing 1.107 (p = 0.615)	NR	NR
Trinkoff, 2013 ²⁹ ; Moderate; Cross-sectional;	NNHS (2004); Total nurse staffing HPRD, dichotomized as ≥ 5.0 vs. <5.0 (88% NH) Skill mix— (RN+LPN)/(RN+LPN+NA) Mean 34% (SD, NR)	MDS (2004); Logistic regression (NH >75th percentile in outcome rate), separate models for NA or licensed nurse (RN+LPN) turnover as main	Pressure ulcer in low and high risk residents: <u>NA turnover model</u> high risk: Staffing 1.01 (0.56, 1.82) Skill mix 1.02 (0.99, 1.05) low risk:	Urinary Tract Infection <u>NA turnover model</u> Staffing 0.77 (0.40, 1.47) Skill Mix 1.02 (1.00, 1.04) <u>Licensed nurse turnover model</u> Staffing 0.68 (0.37, 1.27)	<u>NA turnover model</u> Staffing 0.43 (0.20, 0.93) Skill mix 1.01 (0.98, 1.03) <u>Licensed nurse turnover model</u> Staffing 0.41 (0.19, 0.88) Skill mix 1.02 (0.99, 1.03)



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
1,142 NH national sample		predictor, OR (95% CI)	Staffing 1.21 (0.58, 2.53) Skill mix 1.02 (0.98, 1.05) <u>Licensed nurse turnover model</u> High risk: Staffing 1.18 (0.66, 2.12) Skill mix 1.02 (0.99, 1.04) low risk: Staffing 0.80 (0.38, 1.66) Skill mix 1.02 (0.98, 1.05)	Skill Mix 1.02 (1.00, 1.04)	
Trivedi, 2012 ⁷⁹ ; Moderate; Longitudinal; 308 NH in Oregon, Wisconsin, and Pennsylvania that reported norovirus outbreak	NHC (2009-2010) HPRD, mean (IQR): RN 0.8 (0.7-1.0)	MDS and CDC National Outbreak Reporting System (2009-2010) Mixed effects Poisson regression models to compare NH resident hospitalizations and mortality during norovirus outbreak and non-outbreak periods, stratified by RN HPRD (<0.75, 0.75-0.95, and >0.95)	NR	<u>Hospitalization RR (95%CI)</u> RN HPRD: <0.75 1.10 (1.03-1.19), p=0.006 0.75-0.95 1.13 (1.05-1.21), p=0.001 >0.95 1.04 (.97-1.11), p=0.300 <u>Mortality RR (95%CI)</u> RN HPRD: <0.75 1.26 (1.14-1.40), p<0.001 0.75-0.95 1.01 (0.91-1.12), p=0.87 >0.95 1.06 (0.94-1.19), Pp=0.32	NR



Author, Year; Quality	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Pressure Ulcers	Nursing Home-Associated Infections	Urinary Catheters
Uchida-Nakakoji, 2015 ⁴⁰ ; High; Longitudinal; 84 VA NH (CLCs) national sample	VA payroll data (2003-2008); HPRD, mean (SD): Total nurse staffing 4.6 (1.2) Skill Mix—each type/total staffing, mean (SD): RN 31% (10%), LPN 26% (10%), NA 42% (13%)	MDS (2003-2008) Negative binomial regression models for total counts per NH (UTI, pneumonia and pressure ulcers), case mix adjusted	Composite of UTI, pneumonia, and pressure ulcers IRR (SE) Total staffing: 1 (0.01), p=0.985 Percent RN: 1.233 (0.232), p=0.264 Percent NA: 1.160 (0.180), p=0.336		NR

Abbreviations. AHRF=Area Health Resource File; CDC=Centers for Disease Control and Prevention; CI = confidence interval; CLC=Community Living Center; HPRD = hours per resident day; IQR= Interquartile range; IRR = incident rate ratio; NH= Nursing Home; NHC=Nursing Home Compare (CMS data); NNHS = National Nursing Home Survey; OR = Odds ratio; PBJ = Payroll based journal; PPS = Prospective Payment System; RR=Rate ratio; SEM = Structural Equation Modeling; UTI=urinary tract infection; VA=Department of Veterans Affairs



Appendix Table F-2. Nursing Home Staffing Associations with COVID-19

Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	COVID-19 Results			
Domi, 2021 ⁴⁸ ; High; Repeated time series; 2,501 NH in 17 states (had vaccine clinics as part of Pharmacy Partnership for Long Term Care Program)	PBJ (2020) RN HPRD in 3 categories, %NH in categories across 3 cohorts: ≤0.449—23-30% (low staffing) 0.499–0.987—51-55% (reference) >0.987—51-55% (high staffing)	NHSN (2021) Zero-inflated negative binomial mixed effects regression for number of resident cases and number of resident deaths (due to COVID-19), IRR	Resident COVID-19 Cases: RN low staffing (≤0.499) 0.92, p=0.47 RN high staffing (>0.987) 0.84, p=0.16 Confirmed Resident COVID-19 Deaths: RN low staffing (≤0.499) 1.05, p=0.73 RN high staffing (>0.987) 0.68, p=0.02			
Gorges, 2020 ⁴⁹ ; High; Cross-sectional; 13,167 NH national sample (85% of facilities that had reported data to CMS COVID-19 Nursing Home dataset)	PBJ (2020) Case-mix adjusted HPRD, mean (SD NR): RN 0.7, LPN 0.9, NA 2.3, total nurse staffing 3.9 Skill mix—RN/total nurse staffing, mean (SD NR): 17.9	CMS COVID-19 Nursing Home dataset (2020) 2 separate models per each outcome: 1) RN, LPN, and NA staffing 2) Total nurse staffing and skill mix (all staffing categorized in 3 quantiles—low, middle-reference, and high) 3 NH outcomes: • Any COVID-19 cases (logistic regression) • Any COVID-19 outbreak (logistic regression) • Count of COVID-10 deaths in NH with any cases (hurdle)	Any COVID-19, COVID-19 Outbreak, Deaths, marginal effect (SE) <u>Model 1</u> Low RN 0.838 (0.069)* High RN 1.341 (0.088)** Low LPN 0.975 (0.052) High LPN 1.083 (0.066) Low NA 0.887 (0.058) High NA 1.027 (0.071) <u>Model 2</u> Low total 0.827 (0.071)* High total 1.153 (0.109) Low skill mix 0.887 (0.052)* High skill mix 1.218 (0.078)** *p<0.05; **p<0.01	OR (SE) 0.874 (0.070) 1.031 (0.079) 0.847 (0.073) 1.064 (0.081) 1.001 (0.078) 0.790 (0.058)* 0.924 (0.073) 0.822 (0.057)** 1.018 (0.062) 1.034 (0.069)	OR (SE) -0.415 (0.196)* -0.243 (0.217) -0.702 (0.203) -0.183 (0.197) -0.34 (0.184) -0.981 (0.229)** -0.371 (0.186)* -1.059 (0.229)** -0.389 (0.207) -0.296 (0.195)	



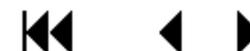
Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	COVID-19 Results
		negative binomial-2 regression) Models not adjusted for case mix	
Harrington, 2020 ¹¹ ; High; Cross-sectional; 1,091 NH in California (272 with COVID-19 cases, 819 without)	PBJ (2019); HPRD, mean (SD): RN 0.6 (0.6), total staffing 4.3 (1.1)	LA County Department of Public Health, California Department of Public Health, and news organizations (March-May 2020) Logistic regression for NH having any COVID-19 cases, separate models for RN and total staffing, not adjusted for case mix, OR (95% CI)	Any COVID-19 Cases RN <0.75 vs. ≥0.75 HPRD: 2.086 (1.318, 3.301) Total staffing <4.1 vs. ≥4.1 HPRD: 1.269 (0.932, 1.72)
Li, 2020 ³⁹ ; Moderate; Cross-sectional; 215 NH in Connecticut	NHC, PBJ (2019); HPRD, mean (IQR): RN 0.7 (0.5-0.8), total staffing 3.7 (3.3-4.0)	News organizations, state agency data (2019-2020); Logistic regression for NH having any confirmed case or death, and linear model (Poisson distribution) for number of cases or deaths in NH with any, case mix adjusted	Resident COVID-19 Cases <u>Any cases, OR (95% CI)</u> RN staffing, per 0.33 HPRD: 0.81 (0.41,1.60), p=0.54 <u>Count of cases, IRR (95% CI)</u> RN staffing, per 0.33 HPRD: 0.78 (0.68, 0.89), p=<0.001 Resident COVID-19 Deaths <u>Any deaths, OR (95% CI)</u> RN staffing, per 0.33 HPRD: 0.62 (0.29, 1.35), p=0.229 <u>Count of cases, IRR (95% CI)</u> RN staffing, per 0.33 HPRD: 0.74 (0.55, 1.00), p=0.047

Abbreviations. CI = confidence interval; HPRD = hours per resident day; IRR = incident rate ratio; IQR=Interquartile range; LPN=Licensed practical nurse; NA=Nursing assistant; NH= Nursing Home; NHC=Nursing Home Compare (CMS data); OR = Odds ratio; PBJ = Payroll based journal; RN=Registered nurse; SD=Standard deviation; SE=Standard error



Appendix Table F-3. Nursing Home Staffing Associations with Resident Pain and Functioning Outcomes

Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Moderate to Severe Pain	Worse Functioning
Arling, 2007 ⁵¹ ; High; Longitudinal; 105 NH (5,242 residents) in Colorado (1998), Indiana (1999), Mississippi (2001), and Minnesota (2004)	Observation and staff self-report (1998-2004); Resident-specific time (RST; hands-on care or administrative tasks for individual residents) HPRD, mean (SD)—RN 0.19 (0.33), LPN 0.34 (0.32), NA 1.29 (0.82) Total direct care (includes RST and tasks for general maintenance or care of unit) HPRD, mean (SD)—licenses staff (RN + LPN) 0.47 (0.23), descriptives NR separately for RN, LPN, or NA	MDS (1998-2004); NR GLM with logit link (presence of ADL decline), case-mix adjusted, coefficients reported with significant p-values marked (otherwise p-values NR)	NR	Decline in ADL (bed mobility, transfer, eating, toileting) in MDS at baseline (closest to staffing data) and 90 days later: <u>RST</u> RN 0.09 LPN 0.13 NA 0.42 (p<.001) <u>Total direct care</u> RN -0.27 LPN 0.25 NA NR
Castle, 2015 ²⁶ ; Moderate; Cross-sectional; 3,939 free-standing NH, ≥30 beds, national sample	NHA survey (2008); FTE per 100 residents (not including agency staff), mean (SD): RN 11.7 (9.3), LPN 14.6 (8.4), NA 30.4 (9.5) % FTE filled by agency staff, mean (SD): RN 9.7% (3.3), LPN 11.2% (3.5), NA 12.1% (4.2) Skill mix—RN/(LPN+NA), mean (SD): 0.25 (0.4)	NH Compare (2008); Negative binomial regression (counts of cases per NH), case-mix adjusted, IRR (95% CI)	Residents (long-stay) with moderate-severe pain: <u>FTE</u> RN 1.02 (0.99, 1.13) LPN 0.98* (0.89, 0.99) NA 0.89* (0.83, 0.98) <u>% agency</u> RN 1.09* (1.02, 1.14) LPN 1.01* (1.00, 1.10) NA 1.05 (0.99, 1.18)	NR



Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Moderate to Severe Pain	Worse Functioning
			Staff mix 0.92*** (0.88, 0.98)	
			*p < 0.05; **p<0.01; ***p <0.001	
Castle, 2011 ³¹ ; Moderate; Longitudinal; 2,839 free-standing NH, ≥30 beds, national sample	NHA survey (2003-2007); FTE per 100 residents (not including agency staff), mean (SD): RN 11.7 (9.3), LPN 14.6 (8.4), NA 30.4 (9.5) % FTE filled by agency staff, mean (SD): RN 9.7% (3.3), LPN 11.2% (3.5), NA 12.1% (4.2) Skill mix—RN/(LPN+NA), mean (SD): 0.25 (0.4)	NH Compare (2003-2007); GMM with Arellano-Bond estimator (change in % residents with outcome, case- adjusted measure), coefficients (SE)	Residents (long-stay) with moderate- severe pain: <u>FTE (per increase of 1)</u> RN -0.53*(0.28) LPN -0.15** (0.05) NA -0.46**(0.17) <u>% agency (per decrease of 1%)</u> RN -0.31*** (0.11) LPN -0.19 (0.08) NA -0.32*(0.02) Skill mix, per increase of 1% -0.15*** (0.03)	NR
			Significant at: * 0.05; ** 0.01; ***0.001	
Castle, 2010 ³⁵ ; Moderate; Cross-sectional; 2,840 free-standing NH, ≥30 beds, national sample	NHA survey (2005); FTE per 100 residents (not including agency staff), mean (SD): RN 12.2 (8.2), LPN 12.5 (6.5), NA 25.8 (7.0) Agency staff FTE per 100 beds, mean (SD): RN 1.6 (1.2), LPN 2.9 (1.9), NA 6.9 (3.4)	NH Compare (2005); SEM path analysis (% residents with outcome, case- adjusted for pain but not functioning), path coefficients p≤0.05 were reported (otherwise NR)	Residents with moderate-severe pain: Long-stay Short-stay <u>FTE</u> RN -0.17 -0.06 LPN -0.14 -0.06 NA -0.06 -0.01 <u>Agency FTE</u> RN NR NR LPN NR NR NA 0.55 0.10	Residents with worse functioning: ADL Mobility (in room) <u>FTE</u> RN -0.06 -0.06 LPN -0.09 -0.05 NA -0.06 0.27 <u>Agency FTE</u> RN NR 0.00 LPN NR NR NA 0.38 0.46



Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Moderate to Severe Pain	Worse Functioning
Castle, 2008 ³⁶ ; Moderate; Cross-sectional; 6,005 free-standing NH, ≥30 beds, national sample	NHA survey (2005-2006), staffing data for 2004; FTE per 100 residents (not including agency staff), mean (SD): RN 11.7 (9.5), LPN 15.6 (8.6), NA 31.4 (9.9) % FTE filled by agency staff, mean (SD): RN 8.7% (3.1), LPN 10.2% (3.4), NA 11.1% (4.6) Skill mix—RN/(LPN+NA), mean (SD): 0.25 (0.4)	NH Compare (2004); Negative binomial regression (count of events per NH), case adjustment NR, coefficients (SE)	Residents with moderate-severe pain: Long-stay Short-stay <u>Log FTE</u> RN 0.771** (0.083) 0.844***(0.052) LPN 1.121 (0.099) 0.867**(0.049) NA 0.954***(0.012) 0.478***(0.106) <u>Log agency %</u> RN 1.184* (0.114) 1.012 (0.030) LPN 0.920 (0.149) 1.019 (0.192) NA 1.081*** (0.030) 1.055*** (0.021) Log skill mix 0.773** (0.082) 0.958 (0.040) *p <0.05; **p <0.01; ***p <0.001.	NR
Castle, 2007 ³³ ; Moderate; Cross-sectional; 1,071 NH in Missouri, Texas, Pennsylvania, New York, Connecticut,	NHA survey (2003); FTE per 100 residents (not including agency staff), mean (SD): RN 14.7 (9.3), LPN 16.6 (8.1), NA 33.4 (10.1) % FTE filled by agency staff, mean (SD): RN 7.7% (12.7),	NH Compare (2003); Negative binomial regression (% residents with outcome, case-adjusted for pain and mobility but	Residents with moderate-severe pain: Long-stay Short-stay <u>Log FTE</u> RN 0.960 (0.136) 1.247 (0.191) LPN 0.987 (0.152) 0.827 (0.143) NA 1.131 (0.253) 0.798	Residents with worse functioning: ADL Mobility (in room) <u>log FTE</u> RN 0.759**(0.064) 0.826**(0.062) LPN 1.123 (0.097) 1.024 (0.063) NA 1.046 (0.148) 0.946 (0.126) <u>Log agency %</u>



Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Moderate to Severe Pain	Worse Functioning
and New Jersey (2 states from each tertile for staff turnover)	LPN 1.9% (3.9), NA 20.2% (18.9)	not ADL), coefficients (SE)	(0.333) <u>Log agency %</u> RN 1.077* (0.033) 1.004 (0.046) LPN 1.034 (0.028) 0.914* (0.038) NA 1.055 (0.059) 1.260** (0.079) Significant at: * 0.05; ** 0.01	RN 1.035* (0.016) 1.054**(0.014) LPN 1.011 (0.017) 1.006 (0.013) NA 1.068* (0.030) 1.058* (0.027) Significant at: * 0.05; ** 0.01
Trinkoff, 2013 ²⁹ ; Moderate; Cross-sectional; 1,142 NH, national sample	National NH Survey (2004, by CDC); Total staffing (RN+LPN+NA) HPRD, dichotomized at < 5.0 or ≥5.0, 88% NH had <5.0 Skill mix— (RN+LPN)/(RN+LPN+NA), mean 34% (SD NR)	MDS (2004); Logistic regression (NH >75 th percentile in outcome rate), separate models for NA or licensed nurse (RN+LPN) turnover as main predictor, OR (95% CI)	Residents with moderate-severe pain (whether long-stay and/or short-stay NR): <u>NA turnover model</u> Total staffing 0.74 (0.37, 1.48) Skill mix 1.00 (0.98, 1.02) <u>Licensed nurse turnover model</u> Total staffing 0.57 (0.29, 1.11) Skill mix 1.00 (0.98, 1.02)	NR

Abbreviations. ADL=Activities of daily living; CI=confidence interval; FTE=Full-time equivalent; GLM=Generalized linear model; GMM=Generalized method of moments; HPRD=Hours per resident day; IRR=Incident rate ratio; LPN=Licensed practical nurse; MDS=Minimum data set; NA=Nursing assistant; NH=Nursing homes; NHA=Nursing home administrator; NR=Not reported; OSCAR=Online Survey Certification and Reporting; RN=Registered nurse; SD=Standard deviation; SE=Standard error; SEM=Structural equations model



Appendix Table F-4. Nursing Home Staffing Associations with Quality of Life

Author, Year; Quality; Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy		Quality of Life (QoL) Results
Abrahamson, 2013 ⁵⁴ ; Moderate; Cross-sectional; 388 NH in Minnesota (random sample of residents)	Minnesota Department of Human Services Statistical and Cost Report (2007) HPRD, mean (SD): RN 0.3 (0.3), LPN 0.7 (0.2), NA 2.3 (0.4)	Resident Quality of Life and Satisfaction with Care Survey (2007), composite score of items from 5 domains (meaningful activities, autonomy, privacy, relationships, and individuality) Mixed effects linear models for composite QoL score, adjusted for case mix, coefficients (SE) and p-values reported	HPRD RN LPN NA	<u>QoL Composite</u> 1.95 (1.82), p=0.285 0.90 (1.26), p=0.478 1.97 (0.74), p=0.008
Shin, 2014 ⁵³ ; Moderate; Cross-sectional; 8 NH (142 long-term residents ≥65 years old) in western New York	OSCAR (2010) HPRD, mean (SD): RN 0.7 (0.2), LPN 0.9 (0.1), NA 2.2 (0.2) Skill-mix—RN/(LPN + NA), mean and SD not reported	Self-reported Quality of Life instrument (2010), 11 domains (comfort, functional competency, privacy, meaningful activity, autonomy, food enjoyment, spiritual well-being, security, individuality, dignity, relationships, and security) and summary score Mixed effects linear models for QoL domains and summary score, adjusted for case mix, t-values reported	HPRD RN LPN NA Skill Mix	<u>QoL Summary Score</u> -5.23 -3.57 1.304 -0.062
Shippee, 2015 ⁵² ; Moderate; Longitudinal; 369 NH in Minnesota (random sample of residents)	Minnesota Department of Human Services (2007-2010) HPRD, mean (SD): RN 0.4 (0.2), LPN 0.7 (0.2), NA 2.4 (0.5)	Resident Quality of Life and Satisfaction with Care Survey (2007-2010), 6 domains (environment, personal attention, food, engagement, negative mood, positive mood) and summary score Mixed effects linear models for QoL domains and summary score, adjusted for case mix, coefficients reported	HPRD RN LPN NA	<u>QoL Summary Score</u> 2.51* 0.09 0.22

Abbreviations. FTE=Full-time equivalent; HPRD=Hours per resident day; LPN=Licensed practical nurse; NA=Nurse assistant; NH=Nursing home; OSCAR=Online Survey Certification and Reporting; QoL=Quality of life; RN=Registered nurse; SD=Standard deviation; SE=Standard error



Appendix Table F-5. Nursing Home Staffing Associations with Hospitalizations

Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Hospitalization Results
Orth, 2021 ⁴² ; Moderate; Cross-sectional; 14,618 NH national sample (191,435 residents with dementia who died in 2017)	Nursing Home Compare (2018) and LTCfocus; HPRD, mean (SD): total 3.8 (0.7) Skill mix—RN/total staffing, mean (SD): 0.16 (0.07)	CMS MedPAR data (2016-2017); Mixed-effects logistic models for odds of resident with potentially avoidable hospitalization within last 90 days of life, case mix adjusted and stratified analyses for severity of dementia, OR (95% CI)	<p>Potentially Avoidable Hospitalizations within last 90 days:</p> <p><u>Mild dementia</u></p> Total staffing (per 10 mins) 1.00 (0.98, 1.01), p=0.58 Skill mix 0.86 (0.76, 0.98), p=0.022
			<p><u>Moderate dementia</u></p> Total staffing (per 10 mins) 1.00 (0.99, 1.01), p=0.57 Skill mix 0.75 (0.68, 0.83), p<0.001
			<p><u>Severe dementia</u></p> Total staffing (per 10 mins) 0.99 (0.98, 1.00), p=0.20 Skill mix 0.73 (0.64, 0.82), p<0.001
Thomas, 2014 ⁴³ ; Moderate; Cross-sectional; 15,356 NH national sample (1,382,477 patients discharged from 3,683 hospitals to NH in 2007)	OSCAR (2006) HPRD, mean (SD): RN 0.4 (0.7), LPN 0.8 (0.8), NA 2.3 (1.1)	Medicare Claims (2007) Cross-classified random effects models for linear probability of readmission within 30 days, case mix adjusted and nurse staffing variables standardized, estimates (SE)	<p>30-day Readmission:</p> RN -0.0019 (0.0009), p=0.03 LPN 0.0007 (0.0009), p=0.47 CNA -0.0014 (0.0007), p=0.05
Xing, 2013 ⁴⁴ ; Moderate; Longitudinal;	CMS Provider of Service, LTCFocus (2006-2007); HPRD, mean (SD): total nurse staffing 3.3 (1.0)	CMS Chronic Care Data Warehouse (2006-2007); Logistic regression for nursing home having worse than average rates of potentially avoidable hospitalizations in the	<p>Potentially Avoidable Hospitalizations within last year:</p> Total staffing 0.94 (0.90–0.99), p=0.02 Skill mix, per 10% higher 0.92 (0.88–0.97), p=0.001



Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Hospitalization Results
11,999 NH national sample (274,774 residents ≥ 65 years old who died in 2007)	Skill mix— RN/(LPN+NA), mean (SD): 0.11 (0.15)	last year of life, case mix adjusted, OR (95% CI)	
O'Malley, 2011 ⁴⁶ ; High; Longitudinal; 67 NH in New York	OSCAR (1998-2004) RN FTE per bed, mean (SD): 0.06 (0.04)	New York State agency data (1998-2004) Accelerated failure time models for time to first hospitalization and time between repeat hospitalizations, case mix adjusted, coefficients	Time to First Hospitalization: 0.11, p=0.10 Time between Hospitalizations: 0.03, p=0.67
Xu, 2021 ⁴⁷ ; Moderate; Longitudinal; 14,600 free-standing NH (≥20 beds), national sample	CASPER (2011-2013) HPRD, mean (SD): total nurse staffing 3.6 (1.0) Skill mix— RN/(RN+LPN), mean (SD): 0.33 (0.19)	Medicare Claims (2011-2013); Generalized Estimating Equations model for rates of hospitalizations per NH per quarter, case mix adjusted, coefficient (SE)	Hospitalizations rates per quarter: Total staffing 0.07 (0.06) Skill mix -0.11 (0.04)* *p<0.05

Abbreviations. CI = confidence interval; CASPER= Certification And Survey Provider Enhanced Reporting system; CMS=Centers for Medicare and Medicaid Services; HPRD=Hours per resident day; LPN=Licensed practical nurse; MedPAR=Medicare Provider Analysis and Review File; NA=Nursing assistant; NH=Nursing Home; NNHS = National Nursing Home Survey; OR = Odds ratio; OSCAR= Online Survey Certification and Reporting system; RN=Registered nurse; SD=standard deviation; SE=standard error



Appendix Table F-6. Nursing Home Staffing Associations Deficiency Citations

Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Outcome Definition; Analytic Strategy	Associations with Deficiency Citations												
Castle, 2011 ⁵⁵ ; Moderate; Cross-sectional; 3,941 free-standing NH, ≥30 beds, national sample	NHA survey (2008), staffing data for 2007; FTE per 100 residents (not including agency staff), mean (SD): RN 10.6 (9.2), LPN 14.5 (8.1), NA 30.1 (9.2) % FTE filled by agency staff, mean (SD): RN 10.9% (3.1), LPN 12.1% (3.6), NA 13.5% (4.0) Skill mix—RN/(LPN+NA), mean (SD): 0.23 (0.5)	OSCAR (2007); Quality of care deficiency citations—sum of 25 citations (F-tags 309-353) addressing ADL and specific care needs, adequate nutrition, medication errors, etc.; Negative binomial regression (counts of deficiency citations per NH), case-mix adjusted, IRR (95% CI)	<u>FTE</u> RN 0.93 (0.80, 1.02) LPN 0.77 (0.56-1.00) NA 1.01 (0.85-1.05) <u>% agency</u> RN 1.18 (0.91-1.25) LPN 1.05* (1.00-1.11) NA 1.11** (1.07-1.21) Staff mix 0.86** (0.81-0.94) Statistically significant at: *p = 0.05 or better; **p=0.01 or better												
Castle, 2011 ⁵⁶ ; Moderate; Longitudinal; 14,934 NH, national sample	OSCAR (2000-2007); FTE per resident, mean (SD) for NH without or with citation in 2000: <table border="1" data-bbox="541 971 877 1149"> <thead> <tr> <th></th> <th>No citation (1,828 NH)</th> <th>Citation (12,372 NH)</th> </tr> </thead> <tbody> <tr> <td>RN</td> <td>0.07 (0.11)</td> <td>0.06 (0.08)</td> </tr> <tr> <td>LPN</td> <td>0.12 (0.09)</td> <td>0.12 (0.08)</td> </tr> <tr> <td>NA</td> <td>0.32 (0.14)</td> <td>0.33 (0.12)</td> </tr> </tbody> </table>		No citation (1,828 NH)	Citation (12,372 NH)	RN	0.07 (0.11)	0.06 (0.08)	LPN	0.12 (0.09)	0.12 (0.08)	NA	0.32 (0.14)	0.33 (0.12)	OSCAR (2000-2007); Deficiency citation F-441 for infection control and hand hygiene; GEE with logit link (NH received citation or not), case-mix adjusted, OR (95% CI)	RN 0.89 (0.84, 0.97) ^{***} LPN 0.92 (0.87, 0.99)* NA 0.91 (0.89, 0.98) ^{***} Statistically significant at: *p = 0.05 or better; **p=0.01 or better; ***p=0.001 or better
	No citation (1,828 NH)	Citation (12,372 NH)													
RN	0.07 (0.11)	0.06 (0.08)													
LPN	0.12 (0.09)	0.12 (0.08)													
NA	0.32 (0.14)	0.33 (0.12)													
Castle, 2011 ⁵⁷ ; High; Longitudinal;	OSCAR (2000-2007); FTE per resident, mean (SD) for NH without any citations: RN 0.07 (0.11), LPN 0.12 (0.09), NA 0.31 (0.14)	OSCAR (2000-2007); Deficiency citations for care safety—any of 5 F-tags: F-332 (medication error rates), F-333 (residents free from medication errors), F-389 (physician available for emergency care), F-431 (drug labeling and storage), F-441 (infection control and hand hygiene);	<u>FTE/100 beds</u> RN 0.95 (0.92, 0.97) ^{**} LPN 1.02([1.00, 1.05])* NA 1.01 (0.99,1.02) Statistically significant at: *p = 0.05 or better; **p=0.01 or better; ***p=0.001 or better												



Author, Year; Quality Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Outcome Definition; Analytic Strategy	Associations with Deficiency Citations	
14,934 NH, national sample		GEE with logit link (NH received citation or not), case-mix adjusted, OR (95% CI)		
Lerner, 2004 ⁵⁸ ;	National NH Survey (2004, by CDC);	OSCAR (2004);	Total staffing 1.03 (0.63, 1.69)	
Moderate;	Total staffing (RN+LPN+NA) HPRD, dichotomized at < 5.0 or ≥5.0, 88% NH had <5.0	Quality of care deficiency citations—sum of 25 citations (ADL, continence, pressure ulcers and range of motion);	Skill mix 0.99 (0.97, 1.01)	
Cross-sectional;				
1,151 NH, national sample	Skill mix— (RN+LPN)/(RN+LPN+NA), mean 34% (SD NR)	Logistic regression (NH >75 th percentile in # of citations), main predictors NA and licensed nurse (RN+LPN) turnover, no case-mix adjustment, OR (95% CI)		
Temkin-Greener, 2007 ⁵⁹ ;	NH Compare (year NR);	OSCAR (2006-2007);	Total Citations Citations	Any G-L
Moderate;	HPRD, mean (SD): RN 0.61 (0.23), LPN 0.83 (0.25), NA 2.31 (0.40)	Quality of care deficiency citations—Sum of 26 citations, whether any G-L in seriousness;	<u>Coeff, p-value</u>	<u>OR, p-value</u>
Cross-sectional;		Total citations—linear regression, standardized coefficients	RN	0.792, 0.395
			LPN	0.837, 0.507
			NA	1.353, 0.191
162 NH in New York, ≥50 beds, open ≥2 years, state-level sample		G-L citations—logistic regression, OR, p-value		

Abbreviations. ADL=Activities of daily living; CI=confidence interval; FTE=Full-time equivalent; GLM=Generalized linear model; GMM=Generalized method of moments; HPRD=Hours per resident day; IRR=Incident rate ratio; LPN=Licensed practical nurse; MDS=Minimum data set; NA=Nursing aide or assistant; NH=Nursing homes; NHA=Nursing home administrator; NR=Not reported; OR=Odds ratio; OSCAR=Online Survey Certification and Reporting; RN=Registered nurse ; SD=Standard deviation ; SE=Standard error; SEM=Structural equations model



Appendix Table F-7. Nursing Home Staffing Associations with Receipt of Antipsychotics, Falls, Discharge to Community, and Mortality

Author, Year; Quality; Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Results
Use of Antipsychotic Medications			
Bowblis, 2010 ⁶⁰ ; Moderate; Repeated time series; 14,743 NH national sample	OSCAR (2000-2005); HPRD, mean (SD): RN 0.3 (0.3), LPN 0.7 (0.4), NA 2.0 (0.7)	MDS (2000-2005); Mixed effects linear regression for rates of antipsychotics use in NH, case mix adjusted, coefficients (SE)	Associations between HPRD and antipsychotic use: RN: 0.16 (0.17) LPN: 0.28 (0.13)* CNA: 0.13 (0.13)* *significant at 5%
Lee, 2014 ²⁸ ; Moderate; Cross-sectional; 195 free-standing NH in Colorado	OSCAR (2000); RN HPRD Mean (SD) [Range]: 0.6 (0.2) [0.2-1.6]	MDS (2000); Ordinary least squares regression model for rates of antipsychotics use in NH, case mix adjusted, coefficients (SE)	Association between RN HPRD and antipsychotic use: 0.176 (4.5) p-value NR but results not highlighted as significant
Falls			
Leland, 2012 ⁶² ; High; Cross-sectional; 15,350 NH national sample (385,545 residents with first NH admission in 2006)	OSCAR (2006) HPRD, mean (SD): nurse (RN + LPN) 1.1 (0.5), NA 2.2 (0.8)	MDS (2006) Fixed effects panel regression	Falls within 30 days after admission to NH: OR (95% CI) Nurse: 1.01 (0.98-1.04) NA: 0.97 (0.95–0.99)
Livingstone, 2019 ⁶¹ ; Moderate;	NHC and CASPER (2013-2016)	NHC (2013-2016)	Percent of long-term care residents experiencing ≥1 fall with bone fracture, joint dislocation, closed head injury, subdermal



Author, Year; Quality; Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Results																				
Repeated time series; 12,352 NH national sample (≥30 residents and in operation for all years between 2013-2016)	HPRD, mean (SD): RN 0.5 (0.4), LPN 0.8 (0.3), NA 2.3 (0.6)	Multilevel random effects regression	hematoma, or altered consciousness (outcome reverse coded; higher is better). Coefficient (Robust SE) RN HPRD: 0.16* (0.06; p<0.05) LPN HPRD: 0.07 (0.05; p=NR) NA HPRD: 0.01 (0.03; p=NR)																				
Discharge to Community																							
Warren ⁶³ ; High; Cross-sectional; 68 NH contracting with SeniorMetrix (6,865 residents with lengths of stay ≤100 days)	OSCAR ^a (2002) total staffing (RN + LPN + NA) HPRD, dichotomized as <3.5 (34% of NH) or ≥ 3.5 (66%)	SeniorMetrix, a private company assisting NH with quality improvement for residents with Medicare Advantage (2002); Multiple logistic regression Staffing and/or skill mix were the primary or secondary focus of the analysis.	For patients in facilities with a nursing staff level of ≥3.5 hours per resident per day, the odds of being discharged to the community were 1.53 (95% CI, 1.29–1.80) times greater than for patients in facilities with a lower nursing staff level.																				
Mortality																							
Tong, 2011 ⁶⁴ ; Moderate; Longitudinal; 612 NH in California with <3.2 total nurse staffing HPRD in 1999	California Office of Statewide Health Planning and Development (1995–2002) HPRD, mean (SD): <table border="1" data-bbox="541 1162 940 1341"> <thead> <tr> <th></th> <th>1995-1999</th> <th>2000-2002</th> </tr> </thead> <tbody> <tr> <td>RN</td> <td>0.3 (0.2)</td> <td>0.3 (0.2)</td> </tr> <tr> <td>LPN</td> <td>0.5 (0.2)</td> <td>0.6 (0.2)</td> </tr> <tr> <td>NA</td> <td>2.0 (0.4)</td> <td>2.3 (0.3)</td> </tr> <tr> <td>Total</td> <td>2.8 (0.6)</td> <td>3.1 (0.4)</td> </tr> </tbody> </table>		1995-1999	2000-2002	RN	0.3 (0.2)	0.3 (0.2)	LPN	0.5 (0.2)	0.6 (0.2)	NA	2.0 (0.4)	2.3 (0.3)	Total	2.8 (0.6)	3.1 (0.4)	California Office of Statewide Health Planning and Development (1995–2002) Ordinary least squares regression for number of residents who died per NH, also 2-stage instrumental variable model, not adjusted for case mix, coefficients (SE)	Association between total nurse staffing and NH resident death: <table border="1" data-bbox="1373 1062 1969 1130"> <thead> <tr> <th>Ordinary least squares</th> <th>Instrumental var</th> </tr> </thead> <tbody> <tr> <td>0.008 (0.646)</td> <td>-6.137 (2.341)*</td> </tr> </tbody> </table> *significant at 1% level		Ordinary least squares	Instrumental var	0.008 (0.646)	-6.137 (2.341)*
	1995-1999	2000-2002																					
RN	0.3 (0.2)	0.3 (0.2)																					
LPN	0.5 (0.2)	0.6 (0.2)																					
NA	2.0 (0.4)	2.3 (0.3)																					
Total	2.8 (0.6)	3.1 (0.4)																					
Ordinary least squares	Instrumental var																						
0.008 (0.646)	-6.137 (2.341)*																						



Author, Year; Quality; Study design; Sample	Nurse Staffing: Data Sources (Year); Definition & Descriptives	Outcome Data Sources (Year); Analytic Strategy	Results
	Estimated nurse staffing using instrumental variable approach (gap between actual total staffing and required 3.2 HPRD, mandated in 2000)		

Abbreviations. AHRF=Area Health Resource File; CI=confidence interval; FTE=Full-time equivalent; HPRD=Hours per resident day; LPN=Licensed practical nurse;; MDS=Minimum Data Set; MH=mental health; NA=Nurse assistant; NH=Nursing home; NHC=Nursing Home Compare; NR=Not reported; NS=Not significant; OR=Odds ratio; OSCAR=Online Survey Certification and Reporting; RN=Registered nurse; SD=Standard deviation; SE=Standard error
^a Reported as Medicare data in study but description (uses NH self-reports and state surveys) consistent with OSCAR data collected by CMS