The forgotten facility: Australia's lax response to controlling antibiotic resistance in nursing homes

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Abstract

Antibiotic resistance poses a significant threat to public health globally. Awareness and measures to address antibiotic resistance in the acute hospital setting are evident and successful, yet the same attention to this in Australian nursing homes is lacking. With Australia's population ageing, a deficit such as this is clearly worrisome. This review examines current strategies that address antibiotic resistance in Australian nursing homes to demonstrate that while infection control strategies are in place in nursing homes, a standardised and comprehensive approach to control antibiotic resistance is absent. One strategy proposed is the implementation of antimicrobial stewardship (AMS) to optimise and regulate the use of antibiotics. In theory, AMS has been proven to be an effective strategy to control antibiotic resistance in nursing homes, however as the determinants of antibiotic resistance in this setting are complex and multifaceted, the practical application of AMS is compromised. Such determinants include a current lack of awareness of AMS by nursing home staff, poor microbiological testing practices, and sociocultural pressures that increase antibiotic prescribing rates and reduce patient compliance to treatment regimes. When combined, these factors have a detrimental effect which acts to increase antibiotic misuse in this setting, strongly correlating with the emergence of antibiotic resistance. This review underscores the lacuna in action focused on overcoming such barriers which clearly hinders our efforts to control antibiotic resistance. Hence, if effective and feasible strategies to address antibiotic resistance are to be developed, further research into the role of the institutional determinants that surround AMS implementation in Australian nursing homes is urgently needed.

Introduction

The threat of antibiotic resistance to public health is a significant global issue that must be addressed (Pringle et al. 2017; Tamma & Cosgrove 2011; Toner et al. 2015). This resistance is driven by the misuse and overprescription of antibiotics for both human and animal use (World Health Organization [WHO] 2014). It is recognised that antibiotic resistance has significant impacts on patient quality of life, the healthcare system, and economic productivity (Australian Commission on Safety and Quality in Health Care [ACSQHC] 2017). The World Health Organization predicts if no action is taken to control resistance, most antibiotics will be ineffective at treating disease by 2050, causing a loss that will exceed US$100 trillion in productivity (Humphreys & Fleck 2016; Wozniak, Graves & Barnett 2018).

Nursing homes are a key element in Australia's healthcare system, providing assistance to Australia's growing older population (Pringle et al. 2017). This is delivered through a multilayered long-term care model that places emphasis on the 'care' of chronic conditions associated with ageing rather than curative treatment (Ergas & Paolucci 2011). In 2015–16, 3.4 million Australian residents were over the age of 65 years (Australian Institute of Health and Welfare [AIHW] 2018). This population group are associated with increased morbidity and the heavy use of health services requiring significant government expenditure to meet these demands (AU$17 billion in 2015–16) (Petrov, Joyce & Gucciardo-Masci 2019). Currently, nursing homes play a significant role in the provision of these aged care services, where 7 per cent of the over-65 population receive nursing home care; almost two-thirds of aged care health expenditure is directed to nursing homes (Khadka et al. 2019). With an ageing

population, the vital role nursing homes provide is projected to increase exponentially (AIHW 2018). Despite this, close attention to how nursing homes contribute to the threat of antibiotic resistance in Australia is lacking (Pringle et al. 2017; Stuart et al. 2012; Van Buul et al. 2012). Together, the high incidence of infection, intense antibiotic use, and close proximity of residents in the nursing home places a selective pressure on bacteria, creating a reservoir of multi-drug resistant organisms (Lim et al. 2014).

The nature of nursing homes means there is increased spread of infection resulting in over-reliance on antibiotics. The elderly population living in nursing homes have an increased susceptibility to infectious disease due to various age-related factors such as a decline in the functioning of the immune system, chronic disease, and comorbidities (Alldred et al. 2016; Cowan et al. 2016; Garibaldi 1999; Krohn 2002). Furthermore, nursing homes require regular social interaction and contact between healthcare staff, patients, and equipment. This creates an ideal environment for resident–resident and nosocomial transmission of infection (Chesky & Stede 2003; Van Buul et al. 2012). These factors contribute to the intense use of antibiotics within nursing homes, with 50–70 per cent of nursing home residents prescribed at least one antibiotic annually (Nicolle et al. 2000; Stuart et al. 2012). It is this intense use of antibiotics in nursing homes that helps to increase the likelihood of inappropriate prescribing behaviour by clinicians. This is shown through inappropriate prescription rates: 20–75 per cent of antibiotics prescribed to nursing home residents are not based on microbiological evidence, but rather on the patient's reported symptoms, perceptions of staff, and family expectations (Avorn & Solomon 2000; Cowan et al. 2016; Friedman 2013; Lim, Kong & Stuart 2014; Nicolle et al. 2000; Stuart et al. 2012).

Despite this overuse of antibiotics there is no clear national program addressing the issue in nursing homes. This is highly concerning as a large body of international research demonstrates the strong correlation between high antibiotic use, and misuse, and the emergence of antibiotic-resistant bacterial strains (Spellberg, Bartlett & Gilbert 2013; Ventola 2015; WHO 2014). This is alarming for Australia's public health as this missing element in Australia's health system limits the capacity to monitor and respond effectively to any potential outbreaks of antibiotic resistance that threaten human and animal health (Stuart et al. 2011). International procedural guidelines have emphasised the importance of implementing strategies to address antibiotic resistance, such as antimicrobial stewardship (AMS) programs (Friedman 2013; Lim et al. 2014).

AMS initiatives aim to reduce the emergence of antibiotic resistance and the associated health and economic costs by optimising judicious antibiotic use (Lim et al. 2014). This is implemented through a multidisciplinary approach where a number of strategies are implemented to address common elements which include leadership and governance, prescriber accountability, education, and microbiological investigation (Centres for Disease Control and Prevention 2014; Nathwani et al. 2019; National Institute for Health and Care Excellence 2015). In Australia, AMS has been readily adopted in acute hospital settings as it has demonstrated clear success in addressing antibiotic resistance, helping to reduce the inappropriate prescribing of antibiotics by 22–36 per cent (McKenzie, Rawlins & Del Mar 2013).

However, despite the observed advantages of AMS in acute care, the implementation of these programs is lacking in Australian nursing homes (Stuart et al. 2012). As the proportion of individuals over the age of 65 within Australia is increasing, the demand for nursing homes will increase significantly (Alldred et al. 2016). Hence, the implementation and evaluation of strategies to control antibiotic resistance in nursing homes will become an even more pressing issue than it is at present (Gadzhanova & Reed 2007; Pringle et al. 2017). This review aims to investigate current AMS strategies in place in Australian nursing homes and to inform future development of policies and procedures to control antibiotic resistance in Australian nursing homes.

Method

Searching strategies

This literature review used a rapid scoping approach to obtain the relevant literature. Search terms were created by searching the key terms 'antibiotic resistance' and 'nursing homes' in the MeSH (Medical

Subject Headings) database to identify how this topic was discussed in the literature. The search strategy used the terms ‘antibiotic resistan*’ OR ‘antimicrobial resistan*’ OR ‘drug resistance, bacterial’ AND ‘nursing home’ OR ‘aged care’ OR ‘old age home’ AND ‘strateg*’. This combination of terms was used as they were specific and directly related to the research question of interest.

Databases used included Scopus, PubMed, Medline, and the Cochrane Library. These databases were selected as they are widely used for health-related research. The initial search of these terms in the selected databases yielded a total of 43,515 results. Search results were further limited to publications that used the English language and that were published between 2013–2018. Results outside these limits were excluded because they are not relevant or comparable to the current Australian nursing home context. Duplicates were removed. These search filters reduced the search result total to 286 articles across the four databases.

Article selection process

Inclusion and exclusion criteria were then devised to screen the 286 search results to identify the relevant literature that specifically addresses antibiotic resistance in Australian nursing homes and the strategies in place to control this. Acute and primary healthcare facilities in Australia were excluded from the search results. Acute healthcare services were identified as care that places an emphasis on curative care over a short time frame. Primary healthcare facilities were defined as services that provide a first point of contact for people requiring medical assistance, often with a focus on preventative healthcare. Both of these healthcare models differ in structure and service delivery to nursing home care, which is more focused on the long-term care of chronic conditions. Due to this difference, acute and primary healthcare facilities were excluded from the review to enable evidence relevant to nursing homes, rather than broad trends in antibiotic resistance in Australia, to be identified. This was critical to gain specific insights into the current factors driving antibiotic resistance—a fundamental step to improve policy development and control resistance. Publications were included that: described the trends or characteristics of antibiotic resistance in Australian nursing homes, investigated the factors contributing to antibiotic resistance in the nursing home more generally, or which explored trends of medication usage and current strategies in nursing homes to address antibiotic resistance. Furthermore, these studies all used participants who were nursing home residents over the age of 65, nursing home staff, or affiliated professionals. Publications were excluded that: were not relevant to the context of Australian nursing homes, were published outside of the selected study time frame, did not address the characteristics of antibiotic resistance within nursing homes, or which focused on healthcare settings outside of nursing home facilities.

The 286 articles found were filtered by examining their abstracts, titles, and keywords. This process yielded 22 articles. The same inclusion and exclusion criteria were used again to screen the full text of these articles and assess their eligibility. After performing this process, a total of four articles qualified for inclusion. A search was also conducted to identify grey literature to seek reports on the practical application of strategies to reduce antibiotic resistance and control infections in Australian nursing homes. This was conducted to complement the earlier search of peer-reviewed articles to try and identify examples of nursing home care guidelines and protocols relating to controlling antibiotic resistance that cannot be accessed through academic databases. A similar search and article selection approach was employed, including the use of the same inclusion and exclusion criteria. This yielded one result eligible for inclusion. Therefore, a total of five articles qualified for deep analysis in this review.

Data collection and charting

Data on the study design, location, sample size, methods, results, discussion, and conclusions were collected to identify the key features of the articles. From this, major themes were identified and included the correlation between clinician prescribing behaviour, the role of the environment in increasing antibiotic resistance, and the interplay of social factors in increasing antibiotic misuse. These themes then formed the primary basis for analysing the current knowledge on antibiotic resistance in nursing homes, the attitudes and perceptions of the role of AMS in controlling antibiotic resistance,

strategies to address antibiotic resistance in place in nursing homes, and the knowledge gaps present in the identified literature.

Results

Major characteristics

There were five Australian studies that were identified as investigating antibiotic resistance and infection control in Australian nursing homes (Bennett et al. 2018; Cowan et al. 2016; Lim et al. 2014; Pringle et al. 2017; Rashid et al. 2018). The major characteristics of the reviewed studies are included in Table 1.

Table 1. Major characteristics of the reviewed studies

Authors	Study design	Topic	Method
Lim et al. (2014)	Descriptive study **Location** Metropolitan and regional Victoria **Sample Size** – 12 high-level nursing homes – 40 nursing staff	– Exploration of the attitudes and perceptions of healthcare providers towards AMS intervention in Australian nursing homes	– Semi-structured interviews and focus groups conducted with GPs, nurses and pharmacists that service nursing homes within regional and metropolitan Victoria
Cowan et al. (2016)	**Study design** Quasi-experiment **Location** South-western Victoria **Sample size** – 2 high-level nursing homes (216 residents collectively) – 60 faecal specimens were collected	– Residential colonisation and environmental contamination of extended-spectrum β-lactamase (ESBL) producing bacteria – The effectiveness of cleaning methods in nursing homes and infection control strategies to control antibiotic resistance	– Residents' faecal specimens were examined to assess residential colonisation – Sampling of the nursing homes' living areas to identify ESBL – Audits of resident infections and prescriptions, and facility cleaning processes were conducted
Bennett et al. (2018)	**Study design** Cross-sectional **Location** Nationwide (67.8% Victoria, 13% Ne South Wales (NSW), 7.2% Western Australia, 6.5% Queensland, 2.7% Tasmania, 2.7% South Australia) **Sample size** – 292 nursing homes (12,319 residents)	– Aims to identify facility and resident-level factors associated with the prescribing of antimicrobials and infection in Australian nursing homes	– Used data from the 2017 Aged Care National Antimicrobial Prescribing Survey (acNAPS) point prevalence study – Survey collected data on infection prevention and prescribing practices, types and prevalence of infections in patients on the survey day, and number of antibiotic prescriptions given
Pringle et al. (2017)	**Study design** Cross-sectional study **Location** NSW Riverina region and the Australian Capital Territory (ACT) **Sample size** – 13 nursing homes from the ACT, 10 nursing homes from regional NSW	– Investigate the perceptions on antibiotic prescribing held by nursing home care managers and pharmacists, and antibiotic prescribing practices in high-level nursing homes in regional NSW and the ACT	– Questionnaires were developed and given to care managers and pharmacists in the Riverina area NSW and the ACT

	– 11 pharmacist responses (location undisclosed)		
Rashid et al. (2018)	**Study design** Cross-sectional study **Location** Nationwide (32.8% NSW, 28.3% Victoria, 16.7% Queensland, 9.3% South Australia, 8.7% Western Australia, 2.8% Tasmania, 1% ACT, 0.4% Northern Territory) **Sample size** – 2,609 responses	– Examined current infection control and antibiotic prescribing practice and policies to control infection outbreaks in Australian nursing homes	– Questionnaires administered collected general data on the nursing home location, number of staff and residents and infection control policies (e.g. vaccination requirements, monitoring and reporting strategies) – Respondents mainly comprised of nursing home managers (67.3%)

Source: Author's summary of Bennett et al. 2018, Cowan et al. 2016, Lim et al. 2014, Pringle et al. 2017 and Rashid et al. 2018.

In examining the areas studied in the reviewed articles, the Northern Territory and Tasmania were not a prominent area of focus for the researchers, with studies specific to these regions lacking (Bennett et al. 2018; Rashid et al. 2018). The sample sizes used across all included studies were relatively small and cannot be generalised to all Australian nursing homes. In comparing these sample sizes to the number of nursing home residents in Australia—total 209,626 (Australian Department of Health 2017)—this sample size accounts for <1.2 per cent of the total population of Australian nursing homes. In combination with the restricted geographic reach of the studies examined, this highlights a concern as limitations in the data collected may compromise the representativeness of the present findings, hindering the ability to assess the current state of antibiotic resistance in Australian nursing homes more broadly. Furthermore, internal validity is also restricted in the study conducted by Pringle et al. (2017) who report low response rates. This indicates the potential for non-response bias to affect the study's reliability and internal validity, reducing the potential for the study's results to be an accurate representation of the sampled population (Fincham 2008).

Four of the studies investigated antibiotic resistance in high-level care, with data from flexible and low-care facilities proportionally lacking in the current literature. High-level care refers to healthcare offering full-time assistance to patients with most daily activities and is often strongly affiliated with allied health services such as physiotherapy (Woods et al. 2011). Comparatively, low-level care facilities are suited to semi-independent elderly patients who require a lower level of assistance (George et al. 2007). Flexible care offers a transitional care approach where assistance is provided over a short period—usually 12 weeks—where the patient receives low-level medical and allied health care and social support with rehabilitation as the primary goal, delaying the transition into nursing home care (Comans et al. 2015).

Longitudinal studies investigating antibiotic resistance in Australian nursing homes are lacking, as all included studies were completed within relatively short time frames. This is a clear limitation present in the current evidence base as it hinders the ability to comprehensively identify the behavioural factors that may encourage antibiotic resistance in nursing homes and how frequently these factors manifest (rare, weekly, daily etc.) (Caruana et al. 2015). In addition to this, the effectiveness of AMS programs cannot be adequately determined in the short term, requiring long-term monitoring in order to understand their effect on controlling antibiotic resistance (Morris & Masterton 2002). Hence, the absence of longitudinal studies in the current knowledge base limits the extent to which the determinants of antibiotic resistance and presence of AMS programs can be assessed.

Determinants of resistance

In order for the effective control of antibiotic resistance to be achieved, it is essential that the determinants of antibiotic resistance present in the nursing home must be identified. Collectively, the reviewed studies demonstrate that these determinants of antibiotic resistance in the nursing home are multifaceted, involving high prescribing rates, limited microbiological testing, and sociocultural

pressures. A key element of this is to identify practices of antibiotic misuse in which antibiotics are prescribed to patients when not deemed appropriate (Byrne et al. 2019; Lim et al. 2015). Identifying such patterns of misuse is imperative to pinpoint factors that contribute the most to encouraging antibiotic resistance and accurately guide resource allocation to support the implementation of AMS programs to minimise the spread of resistance (Lim et al. 2015).

This notion was discussed in four of the included studies, in which a correlation between antibiotic prescribing behaviour and antibiotic resistance was made (Bennett et al. 2018; Cowan et al. 2016; Lim et al. 2014; Pringle et al. 2017). Pringle et al. (2017) report that over 50 per cent of surveyed nursing homes had at least one resident taking antibiotics for an ongoing issue. This is supported by Lim et al. (2014), where concern regarding the long duration of antibiotic prescriptions in nursing homes was raised by several pharmacists. Similarly, Cowan et al. (2016) note that approximately 80 per cent of the residents surveyed have been prescribed at least two courses of antibiotics in the last 12 months; however, only 19.5 per cent of these were based on microbiological testing. This is confirmed by Bennett et al. (2018) who demonstrate that antibiotic prescribing rates were higher than infection prevalence (8.9 per cent vs 2.9 per cent). This significant difference between prescribing rates, infection prevalence, and definitive diagnosis via microbiological testing is characteristic of antibiotic misuse, in which AMS practices do not seem to be prioritised, increasing the vulnerability to antibiotic resistance. The effect of this increased vulnerability is supported by the observation that nursing home residents are more likely to contract an antibiotic-resistant infection if they have been treated with an antibiotic commonly prescribed in this setting, as opposed to treatment with a less commonly prescribed drug (Bennett et al. 2018). Despite there being strong evidence to demonstrate the occurrence of antibiotic misuse in the nursing home, results from Lim et al. (2014) show that some nursing home staff, including nurses, pharmacists and general practitioners (GPs) assert that the current prescription of antibiotics in this setting is not excessive, suggesting that they do not believe antibiotic misuse is an issue in nursing homes. This is concerning as it demonstrates a disconnect between the empirical evidence of antibiotic misuse and hence risk of antibiotic resistance and the perceptions of nursing home staff, which may be a factor hindering the implementation of AMS programs.

The nursing home environment itself was also identified by Cowan et al. (2016) and Lim et al. (2014) as a factor that increases the emergence of antibiotic resistance. Microbiological investigation of the physical environment revealed the presence of multi-drug resistant bacterial cultures in various communal areas of the nursing home, creating potential sources of cross-contamination (Cowan et al. 2016). Moreover, social factors were also identified to contribute to the misuse of antibiotics and the emergence of resistance. Lim et al. (2014) reported that a number of GPs expressed that they felt pressure from resident nursing staff and family to prescribe antibiotics to nursing home residents, leading to unnecessary prescribing. This is supported by common GP practice where antibiotics are prescribed as a precautionary measure rather than in response to infection (Lim et al. 2014).

Strategies in place to reduce antibiotic resistance

All studies demonstrated that most nursing homes have formal procedures for infection control and/or antibiotic prescribing (Bennett et al. 2018; Cowan et al. 2016; Lim et al. 2014; Pringle et al. 2017; Rashid et al. 2018). However, the efficacy of such procedures in controlling antibiotic resistance is questionable. This is evident as present procedures and clinical guidelines lack emphasis on AMS, focusing more on preventing and controlling influenza and gastroenteritis outbreaks (Rashid et al. 2018). This is reflected in the perceptions held by nursing home–affiliated staff regarding stewardship. Most of the nursing staff sampled by Lim et al. (2014) lacked knowledge about when it is appropriate to prescribe antibiotics and were unaware of the concept of AMS. These staff members also expressed that they believed that antibiotic resistance was more relevant to acute care (Lim et al. 2014). These findings are supported by Pringle et al. (2017), who demonstrate that this lack of knowledge about AMS is interdisciplinary: 81 per cent of the pharmacists surveyed were unaware of any formal guidelines regarding antibiotic prescribing in the nursing home setting.

The clinical impact of this unawareness of AMS in nursing homes is demonstrated by the correlation between increased antibiotic prescribing rates and poor compliance to the infection management and

prevention strategies in place in nursing homes (Bennett et al. 2018). This clinical impact concerns patients being prescribed antibiotics as treatment when this may not be the most optimal mode of treatment (Lim et al. 2014). This results in unnecessary antibiotic use, which is considered a key driver of antibiotic resistance (Olesen et al. 2018). Therefore, this lack of compliance to guidelines for appropriate antibiotic use increases the potential for the development of antibiotic resistance. Lim et al. (2014) found that the clinical impact of these perceptions and the current inadequacy of infection control strategies is likely to further foster the emergence of antibiotic-resistant organisms. This also highlights an absence of active engagement and implementation from nursing home staff towards health policies, in addition to the previously discussed poor communication between health professionals. This is concerning, as effective AMS programs require interdisciplinary collaboration to educate clinicians in order to promote the optimal use of medicines (McKenzie, Rawlins & Del Mar 2013). Hence, current strategies to reduce antibiotic resistance in Australian nursing home are ineffective as staff show limited compliance to the nursing home infection control protocols present.

What strategies do staff perceive are needed?

For antibiotic resistance to be effectively controlled in nursing homes, it is imperative that the control measures developed can be easily implemented in this setting and are feasible with the staff and equipment resources available (Anderson et al. 2019). To gain an accurate insight into the feasibility of implementing AMS strategies in nursing homes hence requires investigation into what nursing home staff perceive as necessary to control antibiotic resistance. This notion was investigated by Lim et al. (2014) and Pringle et al. (2017), who demonstrated that consensus between health professionals regarding the potential benefit and need for stewardship were evident when the concept was fully explained. By examining what nursing home staff perceived as the benefits of implementing AMS, Lim et al. (2014) highlighted that while support for AMS in the nursing home is present, the reasons behind this support varied between the health professions. Among GPs it was felt that AMS would promote evidence-based prescribing practices in nursing homes, whereas pharmacists agreed that the main value of AMS was its ability to establish uniformity in prescribing behaviours (Lim et al. 2014). Nursing staff, however, expressed that AMS would be of most benefit as an educational tool to promote staff engaging in optimal prescribing practices (Lim et al. 2014).

This variation in responses highlights that there is a lack of consensus regarding the need, potential use, and benefits of AMS in the nursing homes to control antibiotic resistance. This demonstrates that, while AMS has been proven to be effective in other healthcare settings, uncertainties surrounding AMS and its ability to optimise antibiotic use in the nursing home still remain (Lim et al. 2014; McKenzie, Rawlins & Del Mar 2013). Such variation must be taken into consideration when developing strategies to control antibiotic resistance in nursing homes to ensure that they are appropriate and suited to this setting (Lim et al. 2014). Failure to consider staff perceptions and the evident differences between perceptions may create a barrier that hinders efforts to control the emergence of antibiotic resistance.

Barriers in implementing AMS

There are multiple social, practical, and financial barriers to implementation of AMS in nursing homes. These include differing healthcare models across nursing homes, inadequate financial resources, the varying characteristics and complexity of disease among the nursing home population, pharmacists not being onsite to oversee antibiotic prescribing, in addition to unproductive social dynamics between health professionals (Cowan et al. 2016; Lim et al. 2014; Pringle et al. 2017). Doctor autonomy and the heterogeneity evident in antibiotic prescribing behaviours hinders acceptance of institutional antibiotic guidelines in nursing homes (Lim et al. 2014). The impact of this perceived autonomy held by nursing home–affiliated doctors is also evident in the responses from a cross-sectional study of pharmacists, who believed their overall ability to contribute to optimal prescribing is limited by their lack of patient history knowledge and their opinions not being valued by doctors (Pringle et al. 2017). This perception was supported by data showing GPs expressed views of the role of the pharmacist as irrelevant in the clinical decision-making process (Pringle et al. 2017). Furthermore, this unproductive social dynamic was also present among nursing staff, where nursing staff anticipated that AMS would not be feasible in the nursing home due to the existing high workload (Lim et al. 2014). However, nursing unit

managers did not foresee any major barriers with the implementation of AMS, but rather expressed concern regarding doctors' compliance with the initiative (Lim et al. 2014).

Discussion

As evident, this review investigates the current perceptions and understanding of AMS strategies in place in Australian nursing homes. Such insight highlights that there remains an urgent need to continue to develop strategies, such as AMS, to control antibiotic resistance in nursing homes. However, as made evident in the reviewed literature, for future strategic development to be successful it must consider the determinants of antibiotic resistance present, attitudes held by nursing home staff, and the current poor understanding of AMS in this setting.

A clear strength of the current literature is the identification of the key determinants that contribute to antibiotic resistance in Australian nursing homes. The existing studies illuminate the perceptions held and current lack of awareness of AMS in the nursing home setting, emphasising a strong correlation between high antibiotic prescribing rates and the emergence of antibiotic resistance. Cowan et al.'s (2016) use of standardised microbiological testing enhances this review by enabling a point of comparison with potential future research on the presence of antibiotic-resistant organisms in the nursing home to be made, demonstrating that environmental contamination with antibiotic-resistant organisms is common across nursing homes (Cowan et al. 2016; Stuart et al. 2011). This aids in informing the development and evaluation of strategies to control antibiotic resistance in nursing homes, highlighting that the potential for the transmission of infection via the nursing home environment must be considered.

Additionally, a key strength in the literature reviewed is the identification of the various barriers present when implementing infection control and AMS strategies in the nursing home. The qualitative data collection methods employed by Lim et al. (2014) enabled the perceptions of nursing home staff to be examined. This enhances the existing evidence base by offering insight into what staff perceive as needed to improve current practices and the perceived barriers in addressing this—information that might have not been obtained by using quantitative data collection. This demonstrates the need for more targeted education programs for nursing home–affiliated staff in order to promote AMS.

However, despite agreement between these studies on the *need* for AMS in nursing homes, a clear lacuna is apparent in the current knowledge regarding *how* effective AMS strategies should be implemented. From the insight into the staff dynamics of nursing homes as provided by Lim et al. (2014), it is clear that implementation of effective AMS strategies will require a consideration of the perceptions held by nursing home staff. This is fundamental, as there are a range of internal factors within the nursing home that will create barriers against effectively controlling antibiotic resistance, such as unproductive staff social dynamics, unawareness of AMS, lack of consistency between health professionals, and absence of focus on AMS in current infection control policies. Such considerations will help to involve nursing home staff in the effective introduction of AMS strategies in the nursing home setting, while increasing awareness of the need to address antibiotic resistance (Dyar, Pagani & Pulcini 2015; Lim et al. 2014).

Internationally, the success of AMS in minimising inappropriate antibiotic prescribing and antibiotic resistance in the nursing home is marked (Crnich et al. 2015). Yet research into how to effectively implement AMS in the Australian nursing home context is not clear. As both evident in this review and other research, the antibiotic misuse identified in this setting stems from a lack of understanding and awareness of appropriate antibiotic use by nursing home staff, leading to the unnecessary prescription of antibiotics (Dyar, Pagani & Pulcini 2015). To address this, future research that considers how to address this antibiotic misuse is urgently needed. Such research will be useful in the development of suitable educational programs for nursing home staff as a potential solution to increase their awareness of the importance of appropriate antibiotic use (Fleming, Browne & Byrne 2013). While the regular education and training of nursing home staff is integral for AMS strategies to be successful, further research into developing educational tools to inform patients on how to minimise infection risks, and to understand when antibiotic treatment is appropriate, may help to address the social pressures that often

lead to inappropriate antibiotic prescribing (Dyar, Pagani & Pulcini 2015). Furthermore, as alluded to in this review, among nursing home staff there are clear and differing perceptions regarding antibiotic use between the health professions. Therefore, further action directed at implementing AMS programs in the nursing home must communicate with these differing health professions to ensure that the strategies designed are suited to multidisciplinary application and encourage a uniform understanding of the purpose of AMS among all professionals (Crnich et al. 2015; Lim et al. 2014). As the population of nursing home residents in Australia continues to increase, achieving a consensus on how to implement successful AMS strategies, as well as evaluating future strategies when implemented, will be critical to prevent the emergence of antibiotic-resistant organisms and preserve the effective use of antibiotics (Alldred et al. 2016).

Moreover, the lack of data from certain geographical regions in Australia—specifically the Northern Territory and Tasmania—is a clear cause of concern. Such gaps prevent an accurate national snapshot of the state of antibiotic resistance in nursing homes. This has the potential to introduce bias into the future development of national strategies to control antibiotic resistance in nursing homes, as strategies can only be based off the evidence gathered, which currently favours Victoria and New South Wales. Consequently, such bias may result in the development of AMS strategies that are not suitable for nationwide implementation in Australian nursing homes, thereby limiting the effectiveness of such strategies to address antibiotic resistance (Dyar, Pagani & Pulcini 2015). Nationwide, there are distinct differences in the location, structure of service delivery, and funding within nursing homes, in addition to differing patient demographics and attitudes, such as cultural background, religious beliefs, and overall health status (Baldwin et al. 2015). Furthermore, there are differences in what each nursing home requires in terms of resources, support, and educational services to implement AMS and optimise the control of antibiotic resistance (Mitchell et al. 2019). For effective and feasible strategies and policies to be devised, identification and analysis of these differences between nursing homes in different regions is essential to enable such variation to be accounted for in the strategic development process (Mitchell et al. 2019). However, the current gaps in data regarding the status of antibiotic resistance and presence of AMS strategies in nursing homes in different regions hinders this policy development process as these variations between nursing homes cannot be well accounted for (Cairns et al. 2015).

The narrow geographic focus and consequent lack of a comprehensive national perspective on this issue accentuates the broader inconsistency in the Australian Government's approach to addressing antibiotic resistance in this setting. Internationally, efforts to control the threat of antibiotic resistance are clear as both individual nationals and global health organisations (such as the World Health Organization) have taken active approaches (WHO 2014). A prime example of this is Sweden's integrated and multidisciplinary national strategy—known as Strama—to control antibiotic resistance in all health, agricultural, food, and community settings, which has resulted in significant success in reducing antibiotic resistance (Mölstad, Cars & Struwe 2008). However, despite this and other clear examples of successful strategies, Australia is yet to take a proactive and comprehensive response to combat antibiotic resistance. As a consequence of Australia's languor, some healthcare settings, including nursing homes as discussed in this paper, are highly vulnerable to the threat of antibiotic resistance (ACSQHC 2017; WHO 2014).

While it is clear this fragmentation results in data gaps, the inability to monitor trends in national antibiotic resistance is an even more significant concern. From a national public health perspective, this is alarming as it restricts Australia's capacity to develop effective and relevant action plans and emergency response strategies should an infectious antibiotic-resistant outbreak occur (Stuart et al. 2011). Given the current lack of AMS in Australian nursing homes as demonstrated throughout this paper, such an event would not only negatively impact patient health outcomes in the nursing home setting, but also have detrimental broader social and economic consequences to the Australian community (Toner et al. 2015).

Even more critically, these gaps further weaken the effect of efforts in other healthcare settings, such as the implementation of AMS in acute care, to address antibiotic resistance, placing the overall effectiveness of antibiotic treatment throughout Australia in jeopardy (Degeling et al. 2018; McKenzie, Rawlins & Del Mar 2013). In addition to this, such gaps hinder attempts to address the social norms,

environment, and public attitude towards antibiotic use that have been illustrated to drive antibiotic resistance, further restricting Australia's ability to adequately control antibiotic resistance (Degeling et al. 2018). If specific policies to address these factors on a federal scale are not implemented, the threat of antibiotics becoming an ineffective treatment will become reality (Laxminarayan et al. 2013).

The present studies also fail to consider patient treatment and review as a barrier to the application of AMS in nursing homes. As the majority of care in nursing homes is provided by offsite providers, patient–practitioner contact is limited (Katz et al. 1990; Shield et al. 2005). Consequently, the empirical diagnosis of illness occurs less frequently, increasing prescribing error and the misuse of antibiotics (Crnich et al. 2015). As appropriate prescribing is fundamental for successful AMS initiatives, this institutional structure is a clear barrier in the implementation of AMS, requiring urgent attention in research if it is to be overcome.

It is also unclear how patient compliance with medication affects the emergence of antibiotic resistance. It is known that in settings outside of the nursing home, patient noncompliance to the prescribed antibiotic regime is a significant determinant in increasing resistance (Eells et al. 2016; Kardas 2002). Nursing home residents commonly engage in polypharmacy: the concurrent use of five or more medicines, including both over-the-counter and prescription medications (Hilmer 2008). This complexity means there is increased risk of both intentional and unintentional noncompliance to medication regimes (Alldred et al. 2016). Consequently, noncompliance among nursing home residents is a clear potential determinant in increasing antibiotic resistance in nursing homes and requires further research.

Conclusion

This study demonstrates that antibiotic resistance in the nursing home setting is complex, and strategies to control its emergence are urgently needed. There remains a critical need for more research with a national scope into how to implement sustainable AMS initiatives within the Australian nursing home context that overcome the identified barriers in this setting. For the implementation of AMS in nursing homes to occur, research must be targeted towards evaluating the feasibility of introducing AMS programs into this setting from the perspectives of nursing home residents and affiliated staff.

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