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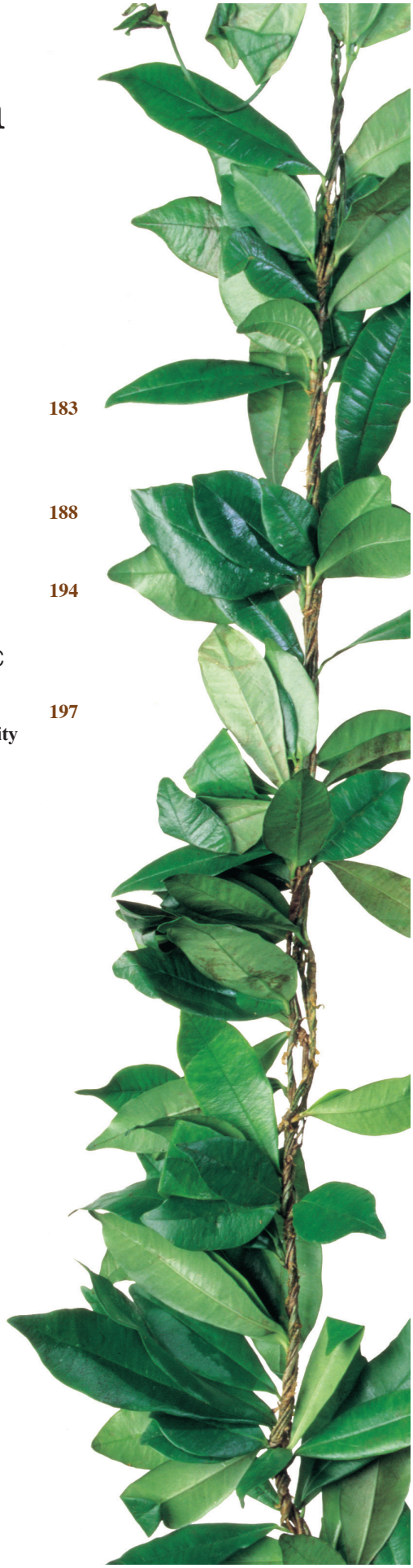

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An Examination of Practices and Barriers of Procedures Performed by Physicians in Rural Hawai‘i

Joseph W. Turban MD; Eun Ah Cho BA; Weston McCue BS; Kelley Withy MD, PhD

Abstract

There is an estimated shortage of 46 000 to 90 000 physicians in the US, especially in rural areas. Physicians working in rural areas often maintain a larger scope of practice compared to their urban counterparts. This scope may include performing procedures which may require additional training, and lack of that training may limit rural physicians' capability to perform procedures. Physicians practicing in rural areas of Hawai‘i were surveyed about their scope of practice regarding procedures and the perceived hindrances in performing procedures. Physicians identified as rural practitioners and rural physicians attending local conferences were asked to participate. Forty-seven (out of 301) rural Hawai‘i physicians participated in the survey, of which 89% reported performing procedures. The most common procedures performed included suture removal, incision and drainage, wound care, and suturing. Of the 47 respondents, a total of 28 physicians or 60% reported wishing to perform procedures but not doing so. The procedures physicians would like to perform included gynecological (36%), casting (21%) and wound care (14%). Barriers to performing procedures included lack of time (51%), inadequate training (37%), out of practice (22%), and poor reimbursement (17%). While most rural physicians in this study perform procedures, many would like to perform more. Lack of training and support are significant barriers to increasing scope of procedures performed. Medical schools, residencies, and continuing education programs should consider expanding training in these areas, especially for those planning to practice or currently practicing in rural areas.

Keywords

procedures in primary care, rural health services, rural medicine, scope of practice

Abbreviations

ED = emergency department
GIS = geographic information system
IUD = intrauterinedevice
PCP = primary care provider
US = United States

Introduction

There is a projected shortage of 46 000 to 90 000 physicians in the United States (US) by 2025, which will be more pronounced in rural areas.[1] Although 20% of the US population lives outside of metropolitan areas, less than 12% of physicians practice in rural areas.[1,2] Concern for recruiting to rural areas is noted not just in the US, but internationally in the UK, Canada, Australia, New Zealand and other countries.[3] Physicians who practice rurally tend to manage more specialty care and are responsible for a broader range of services compared to their urban counterparts.[4] Primary care physicians (PCPs) working in rural areas practice a more diverse spectrum of surgery, maternity, and emergency services than metropolitan providers[5,6] and typically perform more procedures than their urban counterparts.[7] This pattern holds true internationally as well. In Canada, graduating rural physicians report greater experience and competence in performing emergency, diagnostic, and labor and delivery procedures compared to graduates in urban settings.[8] In Germany, rural general practitioners perform more procedures than those in urban areas.[9]

Efforts dedicated to promoting recruitment of rural physicians to decrease the shortage in non-metropolitan areas, including rural residency programs, have been successful.[1] Rural practice tracks in medical school and residency have significantly increased selection of practice in a rural setting.[10] Myhre et al found family medicine graduates of rural programs performed a broader scope of clinical procedures in-office and in-hospital, including postnatal care, intrapartum care, emergency care, and palliative care compared to urban graduates.[11] Likewise, in 14 family medicine residencies across the US, graduates of rural programs reported performing a broader scope of obstetric and hospital procedures, as well as endometrial biopsy, joint injections and aspirations, and fracture care compared to graduates in urban communities.[5] Physicians who practice rurally require increased training to meet this challenge/requirement. Medical schools, residency training, and continuing education programs need to evaluate if physicians training is adequate in this area. The purpose of this study was to describe practices of and barriers to procedures performed by PCPs in rural Hawai‘i.

Methods

An anonymous 9-question survey was developed to determine the type of procedures rural PCPs practice in Hawai‘i. Rural was considered neighboring islands and the O‘ahu areas of: Wai‘anae, Waimānalo, and Wahiawā to Lā‘ie. The survey was developed by the research team to collect information on the physician's specialty, length of time in practice, type of practice setting, procedures performed, procedures physicians seek to perform, barriers preventing performing procedures, distance from nearest emergency department (ED), and space for additional comments. The choices for procedures were: none; splinting; casting; suture removal; suturing/would repair; wound care; incision and drainage; bladder catheterization; colposcopy; endometrial biopsy, intrauterine device (IUD) placement; vasectomy; circumcision; and other (please specify). Options for the question on barriers to performing procedures were: lack

of training; poor reimbursement; not enough time; impinging on other's scope of practice; out of practice; and other (please specify). See **Table 1** for full results.

There are approximately 3500 practicing physicians in Hawai'i, of whom, only 301 are rural PCPs.[12] A survey request was sent to the 189 (of the 301) rural primary care physicians in Hawai'i for whom the research team had email addresses, which netted 5 returned surveys after 30 days. The survey was also administered in hard copy at the 2018 Hawai'i Health Workforce Summit (attended by 220 Hawai'i physicians), and the 2019 Hawai'i Academy of Family Physicians Conference (attended by 135 Hawai'i physicians). A table with surveys was placed in the conference with a sign asking PCPs who practiced in rural areas of the state of Hawai'i to participate. Medical and prehealth students staffed the table to ask rural Hawai'i physicians to complete the survey. A total of 47 eligible physicians completed the survey. Using the total of 301 rural physicians as a denominator, this represented 16% of rural physicians practicing in Hawai'i. Not all responders answered all questions, which resulted in missing data to some questions, as identified in **Table 2**. IRB approval was obtained through the University of Hawai'i Human Subjects Committee, protocol number 2018-00064.

Statistical Analysis

Descriptive statistics are reported as frequency and percentages. Categorical data examining performance of procedures and size of group was analyzed using chi-square. A logistic regression model was performed to examine the relationship between distance to nearest ED and length of time in practice to determine if this may impact the findings. A *P* value of .05 was considered significant. Logistic regression analysis was performed using free statistical software from MedCalc, version 20.218 (MedCalc Software Ltd, Belgium). The chi-square analyses were performed using Social Science Statistics, no version (https://www.socscistatistics.com/tests/chisquare2/default2.aspx).

Table 1. Barriers to Performing Procedures Reported by Hawai'i Primary Care Providers

Barrier	Respondents n = 41 (%)
Not enough time	21 (51)
Lack of training	15 (37)
Out of practice	9 (22)
Poor reimbursement	7 (17)
Lack of equipment	3 (7)
Impinging on other's scope of practice	3 (7)
Cost of equipment	1 (2)
Lack of staff	1 (2)
Large size of medical group	1 (2)

Results

There were initially only 5 responses to the online survey request, which was sent out to approximately 189 physicians. The family physician conference yielded 22 responses and the workforce summit conference contributed 20 responses for a total of 47 participants. A majority of the participants identified as Family Medicine specialists (**Table 2**). The average length of time in practice was 14.8 years (SD:13.8 years) with a range from 4 months to 49 years.

Physician respondents reported group size as: solo practitioners (33%), less than five providers (20%), five or more providers (17%) and medical group/hospital practice (30%). Eighty nine percent of responding physicians reported performing procedures in their offices. A majority (60%) of physicians responded that there were procedures they would like to perform but they did not.

The procedures are listed in **Table 3**. The most common procedure performed was suture removal (100%), followed by wound care (95%), incision and drainage (93%), and suturing and wound repair (74%). The procedures that were not performed but were most desired to perform were casting (26%), endometrial biopsy (26%), and colposcopy (26%), followed by IUD placement (22%), vasectomy (17%), and splinting (17%). The 5 physicians who were not currently performing any listed procedures had no wish to perform procedures. Perceived barriers to performing more procedures included: not enough time (51%), lack of training (37%), out of practice (22%) and poor reimbursement (17%).

There was no statistically significant correlation between distance to nearest ED and performing procedures ($P>.5$). There was a negative correlation between years in practice and performance of procedures (coefficient -0.084319, $P=.0053$, odds ratio 0.9191 [95% confidence interval 0.8662-0.9753]), indicating that more recent graduates in the study reported performing more procedures than physicians who have been in practice longer. There was no association between practice size and desire to perform procedures ($P=.37$).

Table 2. Medical Specialty of Rural Primary Care Respondents in Hawai'i, 2018-2019

Medical Specialty of Respondents	N (%)
Family Medicine	31 (66)
Internal Medicine	9 (19)
Pediatrics	3 (6)
Obstetrics/Gynecology	1 (2)
General Practice	1 (2)
No response	2 (4)
Total	47

Table 3. Medical Procedures Performed by Hawai'i Rural Primary Care Providers and Procedures Providers Would Like to Perform

Medical Procedure (Including write in options)	Respondents who perform N (%)	Respondents who seek to perform N (%)
Bladder catheterization	16 (37)	1 (4)
Casting	9 (21)	6 (26)
Circumcision	7 (16)	1 (4)
Colposcopy	4 (10)	6 (26)
Endometrial biopsy	5 (12)	6 (26)
Incision & drainage	39 (93)	
Intrauterine device placement	16 (37)	5 (22)
Splinting	20 (47)	4 (17)
Suture removal	42 (100)	
Suturing/wound repair	32 (74)	3 (13)
Vasectomy	2 (5)	4 (17)
Wound care	40 (95)	
Write in answers below:		
Biopsies (shave, punch, excisional)/lesion removal	6 (14)	2 (9)
Nexplanon® placement	4 (10)	2 (9)
Injections/Joint injections	3 (7)	1 (4)
Laboratory testing/microscopy	2 (5)	
Colonoscopy		2 (9)
Cryotherapy	2 (5)	
Nail removal	2 (5)	
Spirometry	2 (5)	
Foreign body removal	2 (5)	
Ultrasound	1 (2)	1 (4)
IV placement	1 (2)	
Acupuncture nerve block	1 (2)	
Ear wax removal	1 (2)	
Cosmetic fillers	1 (2)	
Dermatological procedures		1 (4)
Diabetic Eye Exams		1 (4)
Joint aspiration		1 (4)
Endoscopy		1 (4)
Hair restoration		1 (4)
Laser treatment		1 (4)
Lingual frenotomy		1 (4)
Stress test		1 (4)

Suggestions for Improvement

Three themes were highlighted in the open-ended comments section of the survey: increasing student and or residency training (n=4), continuing medical education training (n=4), and reimbursement (n=4). Four physicians suggested increasing medical school or residency training opportunities. For this to happen, more physicians are needed who would be willing to train students on the procedures. Training can be in the form of procedural workshops or as sponsored, focused events.

One physician advocated for family medicine physicians to be able to practice to their true level of ability and comfort, indicating that primary care is the most cost-effective option for care and less expensive than having to send patients to specialists, the ED, or urgent care facilities. Another commented that some continuing medical education and training opportunities are geographically distant and expensive; therefore, they preferred to have training be offered through the medical school. To implement effective training, one suggested contacting regional or out-of-state family practice programs to learn how they train staff to perform clinical procedures.

Three physicians stressed that there is little to no reimbursement within the payment transformation system for office procedures. This may decrease the number and breadth of procedures performed. They noted that there is also no reimbursement for vaccine administration or taking samples for testing. They collectively suggested that to move forward in rural care and reduce costs, there must be better reimbursement. Another commented that the paperwork required by insurance companies was a barrier to performing procedures.

Discussion

Patients in rural Hawai‘i are adversely affected by physician shortages but could be better served if their PCPs were able to perform procedures that they require. The majority of PCPs practicing in rural Hawai‘i responding to this survey perform procedures; however, many would like to expand that aspect of their practice. Perceived barriers to conducting procedures included lack of training, lack of time, and lack of reimbursement. The fact that there were 22 additional procedures described by participants, in addition to the 12 listed on the survey, indicates that rural primary care providers are thinking about performing more procedures. All practices perform suture removal and almost all practices peform incision and drainage, suturing and wound care. Many practices are performing biopsies and joint injections as well as inserting Nexplanon. There is limited interest in other procedures including handheld ultrasound scanning.

Most studies indicate that PCPs practicing in rural areas typically perform more procedures than their suburban and urban counterparts,[4-11] although a report from Canada using academic societies and medical associations does not mention a difference depending on choice of practice location.[13] Current training programs may not be preparing future physicians to practice in rural settings if they do not train in all the procedures needed. Medical schools and residency programs must do more to provide PCPs a broader spectrum of training to care for their patients. In addition, continuing education programs, either hands-on, or possibly by distance learning, can train PCPs in desired procedural skills; therefore, such trainings should be increased.

This study also indicated that payment transformation creates disincentives to perform procedures as there is no additional pay for the effort involved, thereby further discouraging PCPs from doing procedures. Research shows that physicians perform procedures if incentivized.[14] Since the procedures take longer than general visits and are often added time that is not reimbursed, there is no incentive for physicians to perform procedures. Yet, performing more procedures would lower the cost of medicine, as it would decrease ED visits and specialist referrals. It is possible that as the cost of medicine continues to increase, expanded procedural skills may be a viable area for insurance companies to investigate to decrease expenses. If more procedural skills were attained by physicians during medical school and residency, such action would decrease need for travel as well as missed workdays for rural patients. In this era of revisiting managed care, it is likely that funding for procedures would have to be mandated at a state or federal level to encourage additional payment. If that were to occur, and there were time and encouragement to perform procedures, it is likely that patients in rural areas, and even in urban areas, would benefit from a more robust primary care experience and the health system would be more cost-effective.

The results showed physicians who had more recently completed training reported performing more procedures than established physicians. A prior study indicates that family medicine graduates of rural residency programs reported, after 18 months in practice, performing a broader scope of obstetric and hospital procedures, endometrial biopsy, joint injections and aspirations, and fracture care compared to graduates in urban communities.[5] It has also been found that graduates who were exposed to lengthened training (either starting residency in the 4th year of medical school, or a 4th year of residency) were more likely to perform 19 out of 30 procedures at higher rates than residents in shorter training programs.[15] Lack of opportunity would affect willingness to continue performing procedures, since loss of skills can occur when physicians do not have the opportunity to practice procedures regularly. Thus, it is not clear if it is the type of training that impacts tendency to perform procedures, time out from training, or physician preference.

A study conducted in Canada reported an increase in geographic distance from a city of more than 100 000 people led to a broader spectrum of procedures and services.[16] This makes intuitive sense, because the farther a patient is from an urban center, the less likely a procedure is available, therefore there is more need

for physicians to perform procedures. However, the results of this study did not show a statistically significant correlation between distance from the nearest ED and performance of procedures. In this survey, the greatest distance noted to the nearest ED was 40 kilometers [25 miles], suggesting remoteness may be less of a factor in the desire or need to perform more procedures. Hawai‘i's island geography varies significantly from Canada, so this may be an impact of the varied geography and not true distance.

The large representation of family medicine physicians compared to other specialties may be a result of recruitment from the family medicine annual conference. Further studies could examine the association between specialty selection (such as family medicine) and opportunities to expand practice roles among rural practitioners. Another avenue of future study could be confirming these findings in urban practices.

This study sheds light on a desire to learn more procedures among rural physicians in Hawai‘i, however the study has limitations. Being a voluntary survey, it may not encompass an accurate representation of all rural physicians. Practitioners who felt strongly on this subject may represent a majority of the respondents, skewing results. The study had a small sample size to represent rural PCPs in Hawai‘i. For logistical reasons, the survey was limited to 9 questions that were not validated. Given the opportunity, further surveys could investigate demographics including gender, race and age; satisfaction with current practice setting, and comparison of scope of procedural practice with physicians in an urban setting. Although sex was not collected or analyzed, results in the literature have been conflicting regarding associations with sex and increased scope of practice.[16-18]

Study limitations include the fact that only 47 rural primary care physicians answered the survey. The authors estimate that there are 301 rural primary care physicians practicing in Hawai‘i which indicates approximately 16% response rate. While this cannot be assumed to represent the opinions of all primary care physicians in Hawai‘i, it is a good initial study that can inform future research in the area. Perhaps it can be a question asked during residency training or upon relicensure to create a better sample in the future. Furthermore, the questions asked in the survey were not validated questions, but written by the researchers to answer the specific question of what procedures would rural doctors in Hawai‘i like to perform. Large scale surveys across the US would be helpful to create validated questions and inform the full population of primary care providers nationwide.

Conclusion

A majority of the rural PCPs in Hawai‘i surveyed perform medical procedures and would like to increase their scope of practice. Increased procedural training for rural PCPs during residency and medical school would enhance physician skills, reduce need for patients to travel to services, and likely improve health care costs and career satisfaction. Post residency training in gynecologic and orthopedic office procedures, wound care and vasectomy would be beneficial to the rural primary care physician population if the insurers provided payment for performing such procedures, and time were alloted as needed.

Conflict of Interest

None of the authors identify a conflict of interest.

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2021 Writing Contest Undergraduate Winner

A Systematic Review of Antimicrobial Resistance During the COVID-19 Pandemic

Janice S.W. Burnside BA; Opal Vanessa Buchthal DrPH; Uday Patil MLIS, MA

Janice S.W. Burnside

Janice Burnside is a 2021 graduate of the University of Hawai'i at Mānoa with her BA in Public Health. This paper was her capstone project prior to graduation. She plans on earning her MPH in the near future.

Abstract

Antimicrobial-resistant pathogens, or "superbugs," cause more than 35 000 deaths and more than 2.8 million antibiotic-resistant infections in the US each year. Worldwide, antimicrobial resistance (AMR) has claimed at least 700 000 lives per year, including 230 000 from multi-drug resistant (MDR) tuberculosis. AMR-related deaths are projected to increase to 10 million by the year 2050. The use of biocides, improper prescribing of antibiotics for viral infections, prolonged hospital stays, and other issues contribute to AMR. The purpose of this study was to determine whether the COVID-19 pandemic has had an impact on the rates of AMR globally. While it is still early for the results of research studies, 4 articles indicated an increase, 2 found a decrease, and 2 had mixed results. It is possible that this pandemic may be contributing to an increase of medication-resistant infections.

Keywords

antimicrobial resistance, antibiotic resistance, multi-drug resistant, COVID-19

Abbreviations

AMR = antimicrobial resistance
CDC = Centers for Disease Control and Prevention
DFI = diabetic foot infections
DFU = diabetic foot ulcers
DM = diabetes mellitus
DOT = directly observed therapy
ICU = intensive care unit
MDR = multi-drug resistant
MDRGN = multi-drug-resistant-gram-negative
MRSA = methicillin-resistant Staphylococcus aureus
SBI = secondary bacterial infection
SES = socioeconomic status
STI = sexually transmitted infection

The term "superbugs" refers to pathogens that are medication-resistant. They are also known as antibiotic-resistant, multi-drug resistant (MDR), or antimicrobial-resistant (AMR) pathogens. These infections are caused by pathogenic microorganisms such as bacteria or fungi that have evolved to possess medication-resistant genes, therefore rendering treatment ineffective. According to the Centers for Disease Control and Prevention's (CDC's) *Antibiotic Resistance Threats in the United States, 2019* (2019 AR Threats Report), more than 2.8 million antibiotic-resistant infections occur in the US every year, causing more than 35 000 deaths and costing $20 billion in health care expenditures.[1] Globally, AMR causes approximately 700 000 deaths per year and these are projected to increase to 10 million deaths by the year 2050.[2]

COVID-19 has emerged during a time of great concern surrounding antimicrobial resistance. A common method of bacterial control and growth inhibition is the utilization of biocides, such as hand sanitizers, which have increased in use during this pandemic. However, the misuse or ineffective concentrations of alcohol in, for example, homemade hand sanitizers may increase the risk for developing medication-resistant infection.[3] Other risk factors for bacterial co-infection include prolonged hospital stays for COVID-19 positive patients, invasive therapeutic devices such as ventilators, and the misuse and/or improper prescribing of antimicrobials.[4,5] In a study of postmortem examinations of individuals from the 1918 Spanish Flu pandemic, results showed severe changes indicative of bacterial pneumonia. Bacteriologic and histopathologic results consistently implicated secondary bacterial pneumonia caused by common upper-respiratory-tract bacteria in most influenza fatalities.[6]

As such, bacterial co-infections with COVID-19 should be studied in order to devise and implement preventative strategies, which in turn, may address the projected increased rates of AMR.

Prevalence of Co-Infection and AMR

There are many challenges to estimating the burden of AMR. Information is not only limited but often unreliable due to the complex nature and factors of this issue.[7] For example, selection bias can be inherent in determining who is tested for AMR infections, but there is also inconsistency with information, specifically, whether it is even entered into laboratory data systems. Furthermore, it is not uncommon for data sources from both private and public sectors to not collate these data,[8] and this creates an even larger challenge at both national and international levels. Standardized protocols for diagnostic methods, data collection, and data entry are needed. These challenges are further exacerbated in low- and middle-income countries where there is little surveillance, minimal laboratory capacity, and limited access to essential antimicrobials.[8] In an early pilot study, researchers found *Acinetobacter* was present in 83.3% of COVID-positive patients, and 50% of the *Acinetobacter* isolates were multi-drug resistant and most commonly distributed in the COVID-positive group.[9] In another study, 14% (95% CI 5-26%) of critically-ill COVID-19 patients in the intensive care unit (ICU) between March 4, 2020 and June 2, 2020 had bacterial coinfections. Nine multi-drug resistant (MDR) strains represented 6% of the isolates; these included extended-spectrum beta-lactamase *E. coli* (4 strains), MDR *P. aeruginosa* (2 strains), and methicillin-resistant *Staphylococcus aureus* (MRSA) (3 strains).[10] In a recent study of patients admitted to a tertiary-care hospital in India, 13% of admitted patients (151/1179) had a secondary infection; most were infected within 14 days of admission. In this study, patients ages 50 years and older were more likely to develop severe symptoms and/or fatal outcomes; in-hospital mortality rates from *K. pneumoniae* were at 33%, and from *A. baumannii* were 27%. Drug-resistant pathogens were isolated from clinical samples of COVD-19 patients, and overall medication resistance by organism ranged from 9% to as high as 84%.[11]

Risk Factors and Drivers of AMR

While everyone is at risk for the 22 microorganisms listed in the 2019 AR Threats Report, children and older adults are at a higher risk, and immune-compromised individuals are at the highest risk.[12,13] Individuals with sexually transmitted infections (STIs) may also be also at increased risk for co-infection of COVID-19 and AMR, as antibiotic resistance is increasing rapidly in bacteria responsible for specific STIs.[14,15]

Clostridioides difficile, formerly *Clostridium difficile* or more commonly known as "C. diff," is classified as an urgent threat in the CDC's 2019 report. Although commonly viewed as a hospital-acquired infection, recent studies show that approximately 41% of *C. difficile* infections are community-acquired.[16] COVID-19 may be further complicating this picture. There is a relationship between overuse of antiseptics and disinfectants and AMR.[17] Research also suggests that a substantial proportion of COVID-19 patients are receiving antimicrobial therapy, despite relatively few reports of bacterial coinfection.[18]

While socioeconomic status (SES) and race/ethnicity are key factors in the social determinants of health,[19] there is little research defining the relationship between SES, race/ethnicity, and AMR. However, there may be a relationship between low health literacy and antibiotic misuse (1 of the main contributors to AMR). In a recent study on antibiotic misuse, 53.7% of participants admitted having "leftover" antibiotics; among these individuals, 77.0% reported "saving" antibiotics, and 4.6% gave their antibiotics to others.[20] Some patients on limited incomes may stop taking their medication once symptoms ease, in order to save pills in case of another infection, while others may assume that a specific antibiotic can treat health concerns other than the concern for which it was prescribed.[20,21]

Poverty and low health literacy can also support the circulation of practices and beliefs that foster inappropriate antibiotic use. These factors may encourage people to self-medicate against common infections, purchase medications from poorly-regulated drug dispensaries, or consult traditional practitioners for health concerns that require biomedical care.[20] Medicines obtained from traditional practitioners often contain unknown chemical agents mixed with antimicrobials in substandard doses, which foster AMR.[22] Improving access to biomedical health care, as well as more robust capacity within the health care system, such as more diagnostic laboratories, especially in low- to middle-income countries, may help to lower rates of AMR.[22]

The agricultural industry introduces another risk factor. The use of antibiotics in livestock contributes to rising rates of multidrug resistance.[23] In recent years, many countries, including the US, Canada, Japan, and China, have limited or restricted the use of antibiotics in food animals. In some cases, such restrictions have been associated with reductions in AMR in humans, suggesting a causal relationship between antimicrobial usage in animals and AMR in humans.[23]

In a recent epidemiological study examining the patterns of AMR in *Escherichia coli* isolates circulating in humans and livestock, *E. coli* isolates were tested for susceptibility to 13 antimicrobial drugs representing 9 antibiotic classes. High rates of AMR were detected, with 47.6% and 21.1% of isolates displaying resistance to 3 or more and 5 or more antibiotic classes, respectively.[24]

Climate change is another risk factor. Heat has been linked to antibiotic-resistant genes in many gram-negative bacteria. It is also a key factor for horizontal gene transfer, the main mechanism in which bacteria acquire resistance.[25] AMR is not limited to bacterial species.

Finally, natural disasters and/or extreme weather events also lead to infections. For example, flooding can cause water-borne diseases, infections due to overcrowding among people seeking shelter in large public spaces, contaminated water due to sewage spillover, and eutrophication.[25]

Methods

This systematic literature review was conducted to explore whether the COVID-19 pandemic has affected the number of cases of AMR globally.

Criteria for Considering Studies in this Review

Although AMR can occur in viruses, bacteria, and fungi, cases of bacteria and fungi that have become drug and MDR are increasing. In the CDC's 2019 AR Threats Report, only bacterial and fungal pathogens and their threat levels are categorized as urgent, serious, or concerning.[26] As such, for the purpose of this project, viral infections were excluded.

Search Strategy

This review was conducted utilizing PRISMA guidelines (**Figure 1**). A search was conducted via PubMed on the terms "COVID-19" and "Drug Resistance" (including Microbial, Bacterial, Fungal and Multiple). This search yielded 155 results.

References from PubMed were collected and recorded into Zotero. One duplicate was removed, along with 33 articles that did not meet PICOS (a framework used in evidence-based practice that stands for and involves the following criteria: Patient/Population, Intervention, Control/Comparison, Outcome) standards, and the remaining 121 article titles were then screened. Those that did not include reference to AMR or COVID-19 were removed (n=34). Accepted articles were further narrowed down by screening their abstracts (13 removed), and then the full articles looking for quantitative or qualitative studies in humans only (79 removed).

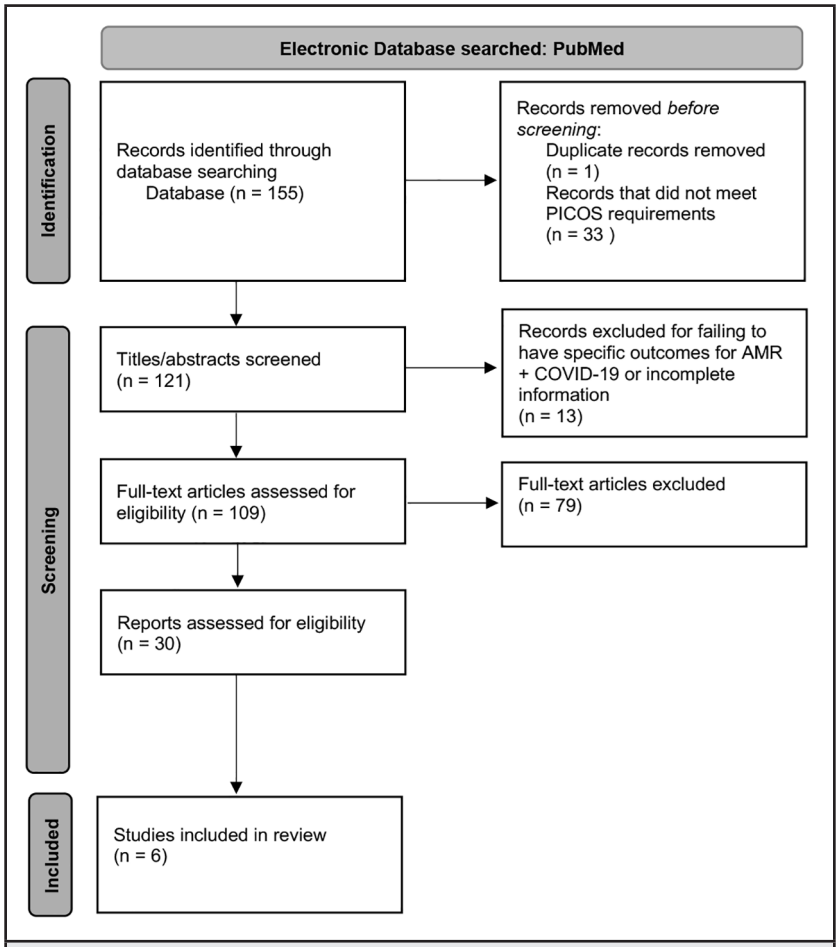

Figure 1. PRISMA Article Selection Flowchart[a]

[a] Figure reflects the flow of information via the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), an evidence-based, minimum set of recommendations designed primarily to encourage transparent and complete reporting of Systematic Reviews.[27]

Results

Out of the 30 articles that met the inclusion criteria, 6 measured the increase or decrease of antimicrobial-resistant infections (**Table 1**). In Gaspar et al, an observational and retrospective study, pre-and post-COVID-19 susceptibility to health care-associated infections in the ICU of a tertiary care hospital in Sao Paulo, Brazil was evaluated. The study population included adults admitted into the ICU and then later transferred to the COVID-19 ICU. Data were retrieved via electronic medical records and microbiological laboratory reports with clinical samples isolated from blood, surgical wounds, catheter tips, urine, tracheal secretions, and rectal swabs. Resistance rates during January 2018 and July 2020 were determined for *S. aureus* resistance to oxacillin (35 resistant cases of 47 total cases), *A. baumannii* resistance to carbapenem (136/173), *K. pneumoniae* resistance to carbapenem (153/246), and *K. pneumoniae* resistance to polymyxin B (153/246). Results revealed an increase of resistance rates during the pandemic for *A. baumannii,* and an even higher rate for *K. pneumoniae* from 5% to 50% for Polymyxin B, an antibiotic used to treat these infections. *K. pneumoniae* was also up 33.3% and the most common pathogen, followed by *A. baumannii* at 27.1%.[28]

In another retrospective study, Caruso et al examined cases of individuals with diabetes mellitus (DM) and diabetic foot ulcers (DFU), at a tertiary care center in Italy, and investigated the rate of antibiotic resistance and its main risk factors for patients with diabetic foot infection (DFI) during the COVID-19 pandemic. From a total of 225 patients with DFI, over the period of January 1, 2019 to December 31, 2020, comparisons were made via microbiological examinations of soft tissues or bone biopsy and were divided as 105 individuals with DM and DFU in 2019, and 120 in 2020. Among the population, 19 patients of the 2019 group, and 63 patients of the 2020 group were admitted with recent or current antibiotic therapy (P<.001). The 2020 group had a higher rate of antibiotic administration (53% vs 79%, P=.044). Of note, compared with 2019, a higher rate of antibiotic self-administration (5% vs 30%, P=.032) and an association with a significant reduction of prescriptions by specialists (79% vs 35%, P=.002) were found in 2020. Results indicated that patients with DFI had a higher incidence of antibiotic resistance in 2020 compared to 2019 from 36% to 63% (P <.001), and previous hospitalization, self-administration of antibiotics, as well as prescription by general practitioners were related to a higher risk of antibiotic-resistant infections.[29]

Another study utilized interrupted time series segmented regression to search for trends in antibiotic use and multi-drug-resistant-gram-negative (MDRGN) acquisition and relationship with COVID-19 in an academic hospital in Maryland. Over a 24-week period from January 5, 2020 to June 7, 2020, researchers looked for COVID-19 related trends, using the same period in 2019 as the control. Data were collected via the hospital's antimicrobial stewardship database that included records of daily dispensed antimicrobials, associated indications, and hospital census divided into 3 categories: total antibiotics, pneumonia antibiotics, and early pneumonia antibiotics (fewer than 7 days from admission). Early pneumonia data captured suspected community-onset bacterial coinfections. To account for the decrease in patient days in 2020 driving changes in antibiotic directly observed therapy (DOT) per 1000 patient days, a separate analysis was conducted of the proportions of DOTs for pneumonia and early pneumonia DOTs in the 2019 and 2020 post-pandemic-onset periods, as well as the monthly proportions of COVID-19 patients who received antibiotics for pneumonia in 2020. MDRGN incidence was measured via the number of clinical cultures per 10 000 patient days, for *Enterobacterales, Pseudomonas aeruginosa,* or *Acinetobacter baumannii* that were non-susceptible to more than 2 of the following antimicrobial agents: piperacillin/tazobactam, cefepime, or carbapenem. Hospital-wide MDRGN incidence and MDRGN

Table 1. Brief Summary of Antimicrobial Resistance During COVID-19 Studies

Lead Author / Year	Location	Summary of Study Findings	Impact on AMR
Gaspar et al, 2023	Sao Paulo, Brazil	*S. aureus* resistance to oxacillin 35/47 (74.4%), *A. baumannii* resistance to carbapenem 136/173 (78.6%), *K. pneumoniae* resistance to carbapenem 155/246 (62.1%), *K. pneumoniae* resistance to polimyxin B 37/246 (15.0%).[28]	Increase
Caruso et al, 2021	Naples, Italy	The incidence of antibiotic resistance among patients with diabetic foot infections was higher in 2020 compared to 2019 (36% vs 63%, P <.001).[29]	Increase
Bork et al, 2020	Maryland, USA	Total antibiotic use and antibiotic use for pneumonia specifically were higher after the onset of COVID-19, with a 3% increase of multi-drug gram-negative acquisition in positive COVID-19 tests per week.[30]	Increase
Cole et al, 2020	Los Angeles, California, USA	Multi-drug resistant organisms decreased from 0.3% per 1000 patient days to 0.2% per 1000 patient-days (P = .03).[31]	Decrease
Bentivegna et al, 2021	Rome, Italy	Higher incidence of 4 MDRO (MRSA, ESBL K. pneumoniae, HA-CD, *A. baumannii*) found in COVID floor patients compared to other departments, but lower in non-COVID floors.[32]	Mixed
Karatas et al, 2021	Bornova, Turkey	Multi-drug resistant *A. baumannii* was higher among COVID-19 patients (9.8%%) than pre-pandemic (3.5%, P < .002), and pandemic era control group (3.1%, P < .001). However, there was a decrease in ESBL-producing *Enterobacterales* (8.9%) compared to pre-pandemic samples (20.8%, P < .001) and pandemic era (20.7%, P < .002).[33]	Mixed

incidence among COVID-19-specific patients were calculated and results indicated that total antibiotic use in general, and specifically for pneumonia were higher after the onset of the pandemic, with a 3% increase of multi-drug gram-negative infection in positive COVID-19 tests per week.[30]

A retrospective cross-sectional study at 4 community hospitals in Los Angeles County, California, reviewed the prevalence of health care onset infections with multi-drug resistant organisms that included MRSA, extended spectrum beta-lactamase (ESBL), and Vancomycin-resistant *Enterococcus* pre-and-post-COVID-19 pandemic to determine the efficacy of an increase in health care workers' compliance with infection prevention. Specimens were collected from urine, wound, blood, or sputum cultures, with only patients who did not have a positive culture for the specific organism until on or after the 4th day of hospital admission. Infection prevention initiatives among health care workers have increased awareness of effective hand washing, cleaning equipment after use, and appropriate personal protective equipment (PPE) use, and the incidence of MDR infection decreased from 0.3% per 1000 patient days to 0.2% per 1000 patient days (P=.03).[31]

In a hospital in Rome, Italy, researchers conducted a case-control study to measure if the incident of MDR bacteria would be lower with preventive measures introduced in 2020. They compared the rates of MDR infections over a 4-month period between March 1 to June 30, in 2017, 2018, and 2019, to the same 4-month period in 2020, when the preventive measures were introduced. Incidence for the 4 most common bacteria (MRSA, ESBL *K. pneumoniae,* HAI (hospital-acquired-infection) *Clostridium difficile,* and *A. baumannii)* on the COVID floor was compared to other departments. During 2020, of the 1617 discharges, both the COVID-19 floor and non-COVID-19 floors showed lower incidences of total MDR infections (MDRI) compared to previous years (45.2% during 2017, 44.2% during 2018, and 41.4% during 2019)(P < .05). However, although lower than pre-pandemic years, the COVID-19 floor did present a higher incidence of all 4 MDRIs than the non-COVID-19 floor (29.2% compared to 19.2%, P <.05).[32]

Lastly, Karatas and colleagues conducted a case-control study at the Ege University Hospital in Izmir, Turkey. With a total of 3534 patients and 4859 positive cultures, they sought to evaluate the epidemiology and AMR patterns of bacterial co-infections and secondary bacterial infections (SBI) in COVID-19 patients and compared the results with 2 control groups of patients with SBIs and bacterial co-infections; from the pre-pandemic era with 2143 patients, and 3034 samples (December 15, 2019 – March 15, 2020) and during the pandemic from 1304 patients, 1702 samples, that did not have a COVID-19 diagnosis (March 16, 2020 – June 15, 2020).[33] Microbiological database records were evaluated retrospectively, and patients with acquired SBIs and bacterial co-infections were analyzed, along with etiology and AMR data of bacterial infections. Data from the 1447 COVID-19 diagnosed patients' were evaluated separately and comprised of 85 patients with 123 bacterial infections. Results were compared from the pre-pandemic control group and the pandemic era control group respectively. Detection of multi-drug resistant *A. baumannii* was significantly higher in patients with COVID-19 compared to the pre-pandemic control group, and the pandemic era control group (9.8%, 3.5% and 3.1%, respectively P <.001). However, there was a significant decrease of ESBL-producing Enterobacterales (8.9%) compared to pre-pandemic control group (20.8% P <.001) and pandemic era control group (20.7%, P < .002).[33]

Discussion

While there were only 6 articles found that indicated the impact of COVID-19 on AMR, it is still relatively early at the time of this paper, and additional studies are warranted for a more comprehensive picture. Regardless, it appears that cases of AMR infections during the COVID-19 pandemic are increasing. While scientists are looking for new antibiotics, and other forms of novel treatments such as nanoparticles and phage therapy, this increase indicates that antibiotic stewardship programs are more important than ever in this global "arms race." This importance has been reiterated throughout the years, including by the World Health Organization (WHO) in April 2014, when it stated that bacterial antibiotic resistance is a current and "major threat," that could affect "anyone, of any age, in any country." Later, in May 2019, at the World Health Assembly, Dr. Tedros Adhanom Ghebreyesus, the WHO Director-General stated that the fight against AMR is one of the most urgent health threats of our time. Nationally, these warnings are also echoed by the CDC in its 2013 and 2019 AR Threats Reports.

Strengths and Limitations

This systematic review relied upon and was limited to only PubMed for the identification of eligible studies. In addition, at the time it was conducted, the pandemic continued to peak all over the world, providing potentially more data on COVID-19 and AMR cases.

Conclusion

The COVID-19 pandemic has highlighted multiple challenges and issues globally with regards to public health and AMR. Earlier in the pandemic, some areas lacked testing and laboratory resources, which resulted in unnecessary antibiotic prescriptions – a known driver of AMR.[8] While aseptic measures were perhaps more vigilantly adhered to and rates of AMR decreased in hospitals, drug-resistant bacterial co-infection rates have increased in COVID-19 units.[32] While this paper was written during the pandemic, infections continue to increase. More recent data would provide a more accurate picture regarding the impact of the COVID-19 pandemic on AMR.

Conflict of Interest

None of the authors identify a conflict of interest.

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A Plan for Action: The Development of a Statewide Initiative to Improve Nurse Wellbeing in Hawai‘i

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The Spotlight on Nursing is a recurring column from the University of Hawai‘i at Mānoa Nancy Atmospera-Walch School of Nursing (NAWSON). It is edited by Holly B. Fontenot PhD, APRN, WHNP-BC, FAAN, FNAP; Research Director for Department of Nursing, Frances A. Matsuda Chair in Women's Health, and Professor for NAWSON, and HJH&SW Contributing Editor; and Joanne R. Loos PhD, Science Writer for NAWSON.

Abbreviations

ANF = American Nurses Foundation
HSCN = Hawai‘i State Center for Nursing
RRW = Recruitment, Retention, and Wellbeing

The wellbeing of nurses has become a priority for health care institutions. The COVID-19 pandemic drew attention to the physical and emotional toll that the profession takes on nurses and causes many to consider leaving the profession. A Google search for the term "nursing wellbeing" returns 129 million results. This reflects the significant concern that has arisen about the wellbeing of nurses. This article describes how and why the Hawai‘i State Center for Nursing (HSCN) is working with its partners and stakeholders to develop a statewide approach to addressing nursing wellbeing as a factor affecting workforce recruitment and retention.

A Crisis of Nursing Wellbeing

The American Nurses Foundation (ANF) conducted a 3-year national study examining the effects of the COVID-19 pandemic on nurses. In November 2022, ANF conducted the third year of the study.[1] Findings indicate that the majority of the nation's nurses feel stressed, frustrated, exhausted, overwhelmed, undervalued, overworked, and anxious. In addition, the proportion of nurses reporting these negative feelings was higher in November than in January of the same year.[2] Also in 2022, the Surgeon General of the United States named health worker burnout a national priority.[3]

While national organizations were studying the impact of the pandemic on nurses across the country, HSCN, a state agency mandated by law to monitor trends in the local nursing workforce and support the recruitment and retention of nurses in Hawai‘i, was doing the same for nurses in the state. To learn about the impact of the pandemic on local nurses, HSCN used its 2021 Nursing Workforce Supply Survey to collect data about nursing wellbeing. Similar to national findings, most Hawai‘i nurses reported that working during the pandemic caused them to feel stressed. Nearly half reported feeling anxious, and about 40% reported they felt exhausted, overworked, and unprepared.[4]

To support employers with their pandemic-related challenges, HSCN began convening regular meetings with nurse executives throughout the state. Early in the pandemic, meetings focused on how HSCN could support health care facilities with the procurement of personal protective equipment or the recruitment of staff to help care for an influx of patients with COVID-19. As the course of the pandemic changed, so did the conversations in these meetings. Rather than focusing on pandemic-related logistics, the nurse executives expressed concern about their nurses' wellbeing and their frustrations with the lack of clear plans for how to address the problem.

HSCN took the growing body of data and the nurse executives' concern as a call to action to strategically address the crisis of nursing wellbeing in Hawai‘i. As a result, in October of 2022, HSCN's Advisory Board endorsed addressing nursing wellbeing as a factor impacting workforce recruitment and retention as an organizational strategic priority. Consistent with the strategic priority, HSCN has produced a report[4] and an infographic,[5] and has offered several continuing nursing education events related to nursing wellbeing. However, the principal activity HSCN has undertaken is to develop clear recommendations to address the wellbeing of all of Hawai‘i's nurses.

Developing a Plan of Action

Defining the Parameters for Statewide Recommendations

HSCN defined 4 primary criteria for the development of a set of recommendations to improve nursing wellbeing in Hawai‘i:

1. Have an impact beyond individual employers or organizations. All nurses deserve wellbeing support regardless of their employers' or organizations' ability to implement wellbeing interventions at work. Recommendations should

focus on multi-employer collaborations or state- or county-level policy changes.

2. Be actionable. Rather than providing abstract suggestions without a clear way to implement them, recommendations should be for specific individuals or organizations to perform specific activities.

3. Be measurable. Recommendations should be accompanied by a reasonable way to measure their outcomes to ensure that less effectual interventions are retired to make way for more impactful ones.

4. Include a combination of short- and long-term activities with short- and long-range outcomes. The recommendations should combine to yield a culture of wellbeing in Hawai'i. To accomplish a culture shift, some activities should be done early with the expectation of rapid outcomes. Other activities should have longer or later implementation times with slower, persistent outcomes.

Forming a Working Group

HSCN leveraged its role as a statewide convener to form the Recruitment, Retention, and Wellbeing (RRW) working group. Invited members were selected to ensure that the plan to improve nursing wellbeing in Hawai'i included perspectives from across the nursing profession. Members included nurses from acute care, post-acute/long-term care, public health, nursing professional organizations, and nursing labor unions. Deans and faculty were invited to represent nursing in academia. Invitees also included nurses from Neighbor Islands to ensure representative voices from across our island geography. To add regulatory, policy, and interprofessional perspectives to the group, HSCN invited the executive officers of the Hawai'i Board of Nursing, the policy analyst from the Healthcare Association of Hawai'i, and the director of the Hawai'i/Pacific Basin Area Health Education Center. Additionally, HSCN Advisory Board members were encouraged to join the working group to provide insight and to help ensure that the work was in keeping with the Advisory Board's vision for the strategic initiative.

Members of the RRW working group were invited to participate in virtual meetings as they were available. Members who were unable to attend were encouraged to participate via email submissions which were added to the discussion by HSCN staff.

Taking an Evidence-Based Approach

The RRW working group's first task was to consult existing academic/scientific literature, commissioned reports, and local news stories about nursing wellbeing. The hope was that existing research would provide tested approaches to improving wellbeing that Hawai'i could adopt. The working group summarized literature[6] describing burnout, compassion fatigue, moral distress, and the consequences they pose for nurses, patients, and health care employers. Despite the large and growing body of literature related to nursing wellbeing, there was no clear evidence of effective interventions or guidance on how to implement them on a large scale.

Concurrent to the RRW working group's efforts, the Nurse Staffing Think Tank Recommendations and Priorities[7] was released. The Nurse Staffing Think Tank is a group of 5 nursing organizations that came together to try to address the sources and consequences of inadequate nursing staffing. The result of their work was a set of actionable recommendations and measurable outcomes for 5 categories that influence nursing staffing and, by extension, nursing wellbeing. The working group compared Hawai'i's identified key issues to the Nurse Staffing Think Tank's priorities and found a high degree of overlap. The document provided not only priority topic areas on which recommendations should focus but also model for a comprehensive set of recommendations.

Early Accomplishments and Future Work

Since its inception in June 2022, the working group has accomplished 3 notable goals including:

1. Summarized current research on nursing wellbeing and burnout and made this summary available on the HSCN Wellbeing Initiatives webpage (https://www.hawaiicenterfornursing.org/wellbeing/).

2. Identified 4 priority areas for interventions: healthy work environments, work schedule flexibility, innovative care delivery models, and total compensation.

3. Identified a planning framework developed by the Centers for Disease Control and Prevention's Environmental Public Health Leadership Institute[8] to help produce actions and measurable outcomes.

The framework will guide the development of a statewide strategy to address nurses' wellbeing, stress, burnout, and their intention to leave their current jobs. Using the framework, the working group will define objectives and measurable outcomes which will be consolidated into a set of achievable recommendations to support the mission of establishing Hawai'i as the best place for nurses to work. Recommendations being developed by the working group include events and activities that can be implemented through the collaborative efforts of employers, state agencies, nursing professional organizations, and other health care stakeholders. These recommendations will address state and county-level public and private sector needs, with a release scheduled for the fall of 2023. Anticipated outcomes will have long- and short-term impacts aimed to improve the wellbeing of and work environments for nurses working in Hawai'i. Future work will focus on prioritizing actions and events to optimize

impacts. Further work will include identifying national, state, and local data resources to measure outcomes. The working group will also identify data gaps and make recommendations for additional data collection strategies to ensure that anticipated outcomes are accomplished.

Conclusion

This statewide strategy to address nurses' wellbeing is a response to a call to action that was created utilizing both national and state level data and resources, as well as eliciting local stakeholder feedback via the working group. The feedback and guidance from the working group has been crucial to the development of an approach to addressing nursing wellbeing that is guided by, framed by, and responsive to Hawai'i's unique needs. The collaborative working group model is an effective way to develop strategic initiatives and can be adopted to facilitate shared decision-making. Moreover, through synergy, the working group model supports partnerships, promotes engagement, and can produce impactful results.

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Tackling the Threats of Antimicrobial Resistance (AMR) through Building Capacity in Laboratory Services in the Pacific Region

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Insights in Public Health is a recurring column from the public health community and is coordinated by HJH&SW Contributing Editor Mapuana Antonio DrPH from the Office of Public Health Studies in the Thompson School of Social Work & Public Health at the at the University of Hawai'i at Mānoa and Contributing Editor Nichole J. Fukuda MS from the Hawai'i Department of Health.

Keywords

antimicrobial resistance, laboratory service, Pacific

Abbreviations

AMR = antimicrobial resistance
AST = antimicrobial susceptibility test
ATCC = American type culture collection
CLSI = Clinical Laboratory Standards Institute
EUCAST = European Committee on Antimicrobial Susceptibility Testing
MROs = multi resistant organisms
PICTs = Pacific island countries and territories
SPC = The Pacific Community

Introduction

Globally, antimicrobial resistance (AMR) is among the top 10 global public health and development threats that require urgent and comprehensive multisectoral actions.[1,2] In 2019, it was estimated that AMR was directly responsible for 1.27 million deaths and associated with 4.95 million deaths worldwide.[3] It is predicted that AMR could kill 10 million people per year by 2050.[4] AMR poses significant threats to the most vulnerable countries that are affected by natural disasters and climate change.[5] Antimicrobials are increasingly ineffective, thus making it harder to treat infections, and consequently causing severe illness. For example, the number of antibiotic resistant tuberculosis strains are increasing and threatening to tackle the tuberculosis epidemic. It is well recognized that the economic impact of AMR is substantial due to prolonged illness, disability, and death.[2] For example, AMR affects the productivity of patients and their families through prolonged hospital stays, intensive care treatment, and/or expensive medications. This compounds the challenges for nations' health care systems and economic development, particularly in the Pacific island countries and territories (PICTs) where resources are limited to effectively address AMR. Of the several drivers contributing to the increase in AMR, this article focuses on the key issues related to laboratory services in the Pacific, countries' efforts in addressing them, and the call for more targeted investment and actions to address AMR in a holistic multisectoral approach.

Key Issues Related to Laboratory Services that are Contributing to the Development of AMR in the Pacific

Evidence has shown that the misuse and overuse of antimicrobials, including antibiotics, antivirals, antifungals, and antiparasitics, are the main drivers of drug resistance.[1,2] In the Pacific, these issues are compounded by the challenges faced in providing quality laboratory services.[5] For example, PICTs have limited: (1) laboratory surveillance systems to properly monitor and generate data on AMR; (2) capacity and skills in testing quality-assured antimicrobial resistance and susceptibility; (3) knowledge on the importance of quality control testing process and resources to detect multi-resistant organisms (MROs); and (4) regulations and guidelines on antimicrobial use among humans and animals.[5] These challenges can lead to poor quality AMR reports and unreliable antibiograms, resulting in the use of inappropriate antibiotics and further worsening AMR in the region.

The development of an accurate and reliable antibiogram at a national level can only be achieved if microbiologists are properly trained, have the required resources to perform a quality antimicrobial susceptibility testing (AST), and implement quality assurance in all processes. These include the pre-analytical phase (eg, collection of samples and transportation to laboratories), the analytical phase (eg, processing of samples in which organisms are grown, identified, and undergo antibiotic testing), and the post analytical phase (eg, reporting of AST results following approved international guidelines, such as from the Clinical and Laboratory Standards Institute [CLSI] and the European Committee on Antimicrobial Susceptibility Testing [EUCAST].[6]

Quality-assured ASTs are critical given that the use of appropriate antimicrobials against specific pathogens is guided

through AST results. ASTs need to be done properly to yield timely, accurate, and reliable results to guide clinicians in the selection of effective antimicrobial agents to properly treat patients. However, the capacity and capability of microbiology testing in low resourced small island developing states across the Pacific region have been a major concern[5] and there is an urgent need to upskill laboratory services. For example, most of the laboratories in PICTs do not have qualified microbiologists and there has been little attention from respective governments and donor agencies to invest in building laboratory capacity to improve services.[5]

Efforts in Addressing AMR through Building Capacity on Laboratory Services

Recognizing the challenges, the Pacific Community (SPC)'s Public Health Division collaborated with Fiji National University, Pacific Islands Health Officers Associations, Pacific Pathology Training Centre, and World Health Organization to develop a training program. The aim of the training program was to build capacity among health workers in PICTs and strengthen microbiology diagnostic capacity to obtain accurate and reliable AST results. This would, in turn, guide informed decisions and the appropriate use of antimicrobials, thereby protecting nations' health care systems against the threat of AMR.

The training program consisted of both theory and practical components and focused on clinical and diagnostic microbiology. This included laboratory methods of conducting ASTs to detect MROs and strengthen AMR surveillance in Biosafety Level 1 laboratories (ie, the lowest level laboratories which work with agents that usually pose a minimal potential threat to laboratory workers and the environment, and do not consistently cause disease in healthy adults). Between 2019 and 2022 the program expanded to multiple PICTs, including Kiribati, Samoa, Cook Islands, Vanuatu, Nauru, Fiji, Tonga, Solomon Islands, Tuvalu, and Vanuatu. A pre and post knowledge test was conducted, and it was reported that both laboratory staff and health care professionals were fully engaged, actively participated, and improved knowledge through the program. The program also provided funding to PICTs for the purchase of necessary equipment and consumables, such as semi-automated urine analysers (to assist microbiology staff in the selection of urine samples that should be cultured for detection of urinary tract infections) and American Type Culture Collection (ATCC) control strains. In addition, the program supported the establishment of a database system and development of design for laboratory antibiogram databases that would allow to monitor AMR patterns and trigger prompt actions on AMR.

Through these regional and national efforts, some positive outcomes have been observed. For example, based on a program evaluation survey carried out 6 months after the training program, the preliminary findings showed that laboratory technicians and microbiology scientists improved their knowledge and acquired practical skills in complying with laboratory protocol in detection of MROs, using proper microbiology procedures to identify AMR strains, testing antimicrobial susceptibility of microorganisms in a quality assured manner, and developing antibiogram that would guide clinicians to the appropriate use of antimicrobials. This would thereby strengthen the nation's health care system.

The Need for More Targeted Investment to Address AMR in a Holistic Multisectoral Approach

AMR is a complex problem that requires a holistic multisectoral approach. Insufficient clean water, lack of proper sanitation and personal hygiene, and inadequate infection control can also lead to the spread of antimicrobial resistant pathogens.[7] The lack of knowledge and the misuse of antimicrobials among the general population could accelerate antimicrobial resistance. The misuse or overuse of antimicrobials in agriculture and animal farms is also major concern, as this could increase the risk of antimicrobial resistant pathogens transmitted from animals to humans.[2] The lack of political leadership and effective governance at the national level to address AMR more effectively also contributes to the growing burden of drug resistant strains.[8]

Therefore, building up laboratory capacity alone will not be sufficient to address the problem of AMR in the Pacific. There is an urgent need to bring relevant sectors and stakeholders together to plan and implement AMR prevention and control programs for better public health outcomes, including the development of effective policies, legislations, education, awareness, behaviour change, monitoring, and evaluation. Targeted investments are required for the research and development of effective antimicrobial medicines and diagnostic methods in all health care settings. It is of utmost importance to ensure all stakeholders are fully aware of the substantial burden of AMR and to address this in a whole-of-government and whole-of-society approach. Addressing AMR in a comprehensive approach will lead to positive health outcomes and contribute to achieving the Healthy Island Vision[9] and United Nations' Sustainable Development Goal 3[10] on good health and well-being.

Conclusion

AMR is a critical development threat, particularly in the low-resourced small island nations in the Pacific. Of the several factors contributing to the increase in AMR, this article highlights the key issues of surveillance and monitoring of AMR, and current efforts in building up laboratory capacity and services in PICTs. Despite recent efforts that have been made, including the creation of a training program, there is still a need to scale up actions that address AMR to attain better health outcomes in the Pacific. Targeted investment and accelerated actions to tackle AMR in a holistic multisectoral approach is urgently needed.

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