The use of telemedicine, wearables, and AI to supplement increasing physician-staffing shortages in rural areas, improve patient-provider connectivity and help sustain patients' residency.

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Abstract: On average, it takes rural residents of the United States over 30 minutes to reach a primary care provider. The technologies of telemedicine, wearables, and artificial intelligence in healthcare have all become more widely accepted as their advancements have progressed through the years. The systematic literature review aimed to determine whether the use of telemedicine, wearables, and AI to supplement increasing physician-staffing shortages within the rural areas of the United States can improve patient-provider connectivity and help sustain these patients' rural residency. A search of literature transpired using PubMed and Wiley Online Library academic databases following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Data from 21 relevant articles were thematically analyzed using screening criteria directly related to the research question, which identified five main themes. The themes included telemedicine in rural healthcare, 67%; wearables in healthcare, 38%; artificial intelligence in rural healthcare, 29%; physician shortage in rural areas, 48%; and internet connectivity, 62%. The findings and results indicated that the increased usage of telemedicine has become a practical solution for alleviating the shortage of physicians; wearables allow for a shift of personal responsibility to the patient; and artificial intelligence has proven itself to perform standardized practices involved in healthcare in order for medical staff to focus solely on the patient and their treatment. The findings of this study imply that the use of telemedicine, wearables, and artificial intelligence to supplement the increasing shortage of physicians within the rural areas of the United States assist in expanding patient-provider connectivity, as well as help sustain patients' rural residency. In addition, the implications of these findings provide healthcare leaders ample justification for ensuring their treatment facility has access to a modern internet infrastructure and the latest in telemedicine technology, as well as to push their legislators to enact laws to eliminate interstate telemedicine restrictions.

Keywords: telemedicine, wearables, AI

Introduction

A 2020 article, utilizing 2017 data on the primary care provider workforce in Iowa, found that for approximately twenty-five percent of their rural population, it can take over 30 minutes to reach a primary care provider within the state; this is consistent with surveys conducted throughout the United States. The contrast becomes more apparent that there needs to be some kind of intervention or supplement for these rural residents within the borders of the U.S. when compared to urban and suburban counterparts who, on average, live within five miles or approximately fifteen minutes from a medical treatment facility (MTF) [19]. Despite the demand for primary care physicians, only 25 percent of medical students choose to pursue a primary care practice, with only five percent of physicians who practice in the primary care field choosing to work in rural communities. The technologies of telemedicine, wearables, and Artificial Intelligence (AI) in healthcare have all become more widely accepted as their advancements have progressed through the years. These could all be used as a relief to help offset the number of practicing physicians continuing to decline annually in rural America, as well as to mitigate the distance from medical assistance [16,17].

The concept of telemedicine dates back to symptoms being hand-carried in a message to someone known to have healing knowledge and a possible diagnosis, as well as how to treat the individual sent back to the caregiver. Makkar et al. define telemedicine as utilizing information and communication technologies to assist in providing medical treatment in lieu of physical contact between a physician and their patient across a distance [17]. Both civilian and military communities now widely accept and use telemedicine throughout the world - in both peacetime, humanitarian missions, and combat operations - through its revolutionary breakthroughs from landline to radio, satellite communications, then to wireless mobile networks (3G and 4G) and finally fiber-optic cable being the fastest mode of telecommunication. The technology of telemedicine has become a viable option when faced with emergency situations, although it is mostly used as a secondary option when a physician is not available. Still, telemedicine continues to prove it can be the standard of care when all the right tools are put in place, which holds true now more than ever, across the globe in 2020 [12,13,].

A wearable is a technological device placed in contact with the skin or inserted into the body either through an orifice or through a surgical incision. Wearables can administer drugs or obtain and transmit the user's biochemical or electrophysical signals in real-time. Wearables have made leaps and bounds over the years with their ability to monitor at-risk patients through their connections via wi-fi (wireless fidelity), Bluetooth, or cellular technology to transfer multiple biofunctions in real-time - especially during an emergency situation. Wearables can send these signals to their provider's service or interface with the patient's smartphone that can provide an analysis of the wearer's health when programmed with the task and coupled with AI.

This is a sharp contrast to when patients were tethered to a cable attached to a monitoring computer (stress test) in the doctor's office just a decade ago [2].

AI is the next step in attempting to alleviate the necessity for more doctors in rural America. AI could eventually have the benefit of having access to every medical textbook ever produced and medical research project ever conducted, as well as integrating with every supercomputer that contains all the symptoms, diagnostic test run, and treatment from every computerized physician order entry system. While at this point in time, the AI interface platform may not be able to personally conduct a physical exam of a patient; however, with the use of wearables, hand-held imaging devices, and some point-of-care lab analysis instruments, this is not as far-fetched an idea as a layperson might assume, as robot-assisted surgery already utilize AI to complete some of the redundant tasks under the supervision of the surgeon. The purpose of this study was to determine whether the use of telemedicine, wearables, and AI to supplement increasing physician-staffing shortages in rural areas improve patient-provider connectivity and help sustain patients' residency [8].

Methods

The literature search process used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. PRISMA guidelines include searching for pertinent studies, screening for inclusion and exclusion criteria, data extraction based on the screening criteria, synthesis of the data to identify key themes, and finally reporting the findings [22,23]. The process used for selecting the articles in this review is illustrated in Figure 1. After utilizing Google Scholar to narrow the topic choice, the author then conducted systematic literature research using the PubMed and Wiley Online Library research databases based on the research question; Does the use of telemedicine, wearables, and AI to supplement increasing physician-staffing shortages in rural areas improve patient-provider connectivity, and help sustain patients' residency? The purposeful exclusion of Google Scholar occurred due to an excessive amount of unrelated results with the broad search terms. Studies and reviews published in 2020 captured the most current material on the topic. The search process with keywords included the use of Boolean search operators and quotation marks for exact phrases for the purpose of producing more focused and productive results. The key terms used in the search included the following: use of telemedicine in rural healthcare of United States; wearables in healthcare of United States; use of Artificial Intelligence in rural healthcare; physician shortage in rural United States; and internet connectivity within the rural United States. The initial search yielded 16,944 results combined.

Exclusion Criteria. The author applied filters to both PubMed and Wiley Online Libraries to exclude articles outside of the selected study time frame of January through June of 2020 and those not included in academic peer-reviewed journals. Additional filters included free full text (open access content) only and to return results only in the English language. These filters excluded 16,888 articles.

The author screened the remaining 56 articles and decided as to whether the article was germane to the study, as well as removed duplicate articles. This exclusion process was completely manual and removed an additional 35 articles. Of the articles excluded, most had a relationship to "use of wearables in rural healthcare." However, these articles did not accurately match the primary search criteria. The final sample included 21 articles.
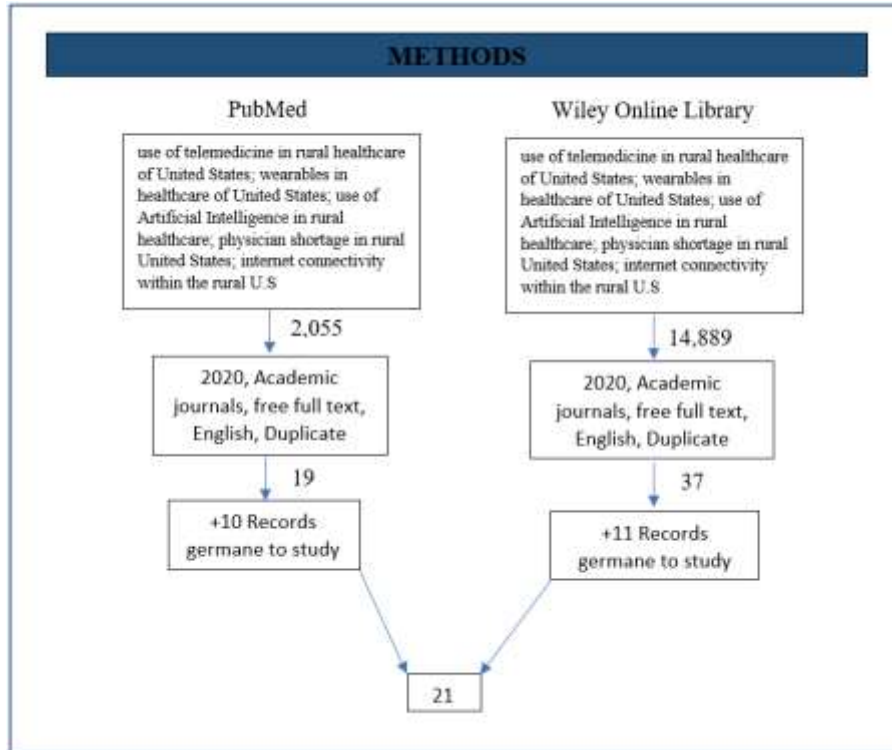
Fig. 1. *Literature Review Process*

Results. The purpose of this study was to determine whether the use of telemedicine, wearables, and AI to supplement increasing physician-staffing shortages in rural areas improve patient-provider connectivity and help sustain patients' residency. An intense literature search and review transpired that used two academic electronic databases – PubMed and Wiley Online Libraries. The author used an established literature search, selection and data analysis process [22,23]. Based on the data from 56 studies chosen, 21 of the articles were relevant to the research question. A final decision transpired by comparing and finalizing the summary findings from each article (see Figure 1). Table 1 lists the title of the articles and key summation findings from these 21 articles.

Table 1. *Summarized findings of the literature*

Title	Findings
[1] The Digital Health Revolution and People with Disabilities: Perspective from the United States.	This article discussed how there has been a shift in getting people more involved in their own personal healthcare; and with the evolution of communication and digital health technologies, this has become more practical and obtainable for the masses. The main issue the article addressed was getting these technologies into the hands of people with disabilities and those in need of medical rehabilitation. One of the key facts brought up was that there is a global estimate of approximately one-billion people who have some type and degree of disability; that is 15% of the population. The article discussed major changes to the reimbursement for medical rehabilitation services within the United States, one of which requires health insurance companies to cover "rehabilitative and habilitative services and devices." Frequent issues encountered with patients who receive outpatient rehabilitative services, as compared to inpatient services, are those of measuring gains and losses of a patients' functions over time, as well as adherence to instructions for exercise. The use of real-time data capture integrated into digital health devices combined with Artificial Intelligence could potentially be the key to improving patient adherence, cost effective outpatient services, availability for disabled patients without access to transportation, and the ability to stretch out follow-up appointments. The article brought up the largest hurdles of all the technologies, which is acceptance of the wearables, AI, and less personal contact with their primary care provider. Authors utilized results from their 2019 survey provided to over 500 rehabilitation practitioners within the United States to develop this article.

[2] Technology anxiety and resistance to change behavioral study of a wearable cardiac warming system using an extended TAM for older adults.	This article discussed high-risk and elderly patients' perceptions and anxieties from advancements in wearables' technology and the use of it for treatment and diagnosis of health conditions, as well as their resistance to utilizing them. The study's main focus was toward cardiac patients and the utilization of wearables, in particular "smart clothing," for detecting abnormal heart conditions that may not be noticed during a regular heart check and could assist in acceptance by older patients. The user's attitude and behavioral intention was measured and displayed in their hypothesis development through a model called the technology acceptance model. There were two constructs that determined the user's attitude toward the wearables' technology: perception of ease of use and perception of usefulness in accomplishing the task. Authors developed a total of 13 hypotheses (older adults with cardiovascular disease) along with their null hypotheses (older adults in general) involving the wearables technology; they are as follows: technology anxiety (4), resistance to change (4), perceived ubiquity, and perceived usefulness, perceived ease of use, and attitude (4). There were 81 participants in the one-year study: 50 older adults and 31 older adults with cardiovascular disease.
[3] Assessing Real-Time Moderation for Developing Adaptive Mobile Health Interventions for Medical Interns: Micro-Randomized Trial.	Although the article was written for the Journal of Medical Internet Research, there is no mention of internet connectivity; however, mobile devices are brought up for their capabilities of delivering just-in-time adaptive interventions (JITAIs). The article is more heavily concentrated on wearables using them for medical interns that targeted three categories of behavior: mood, activity, and sleep.
[4] Wearable Sensor System to Monitor Physical Activity and the Physiological Effects of Heat Exposure.	The article was written on the platform promoting the utilization and benefits of non-invasive wearable technology for older adults and other vulnerable populations, as well as athletes and military personnel. The article goes into detail about how wearables could be used to prevent heat-related injuries. Sixteen human test subjects were run through a series of five different physical activities, all while connected to both the test measuring device developed by the authors and a commercial pulse oximeter during a study conducted at the University of California, Davis.
[5] Adherence with blood pressure monitoring wearable device among the elderly with hypertension: The case of rural China.	A three-month study utilized a 12-hour ambulatory blood pressure monitor to assess blood pressure within a rural population. All of the hourly measurements were automated in order to negate any reliance on the studied population.
[6] A Novel Fracture Prediction Model Using Machine Learning in a Community- Based Cohort.	A study evaluated 2,227 Korean participants over a 2.5 to 10-year period to develop a new fracture prediction model by testing three different models which utilize AI in their prediction methods. During the study, there were limitations discovered that determined the predictors may not be easy to apply in a real-world setting. The determinate was that future studies needed to involve other ethnicities to further validate the findings.
[7] Qualitative and quantitative approach to assess of the potential for automating administrative tasks in general practice.	A 330-hour observation study, in six different medical offices located in England, was conducted to determine if administrative tasks of primary care staff could be taken over by AI. The study concluded that approximately 44% of the administrative duties could "mostly or completely" be taken over by available technology.

Table 1. Continued.

Title	Findings

[8] Advanced Intelligent Systems for Surgical Robotics.	The article described all of the advances in modern technology that have revolutionized the field of surgery. These advances have allowed it to become less invasive and has all but eliminated conventional open surgery. The article went into detail about the limitations of performing laparoscopic utilizing minimally invasive surgical techniques due to the 2-D image and lack of haptic feedback (sense of touch). However, the patient benefits of reductions in trauma, blood loss, healing time, and scarring, as well as faster recovery and improved diagnostic outcomes all overshadow those limitations. Of all the advancements, robot-assisted surgery is quickly becoming the standard practice in order to overcome major limitations when utilizing minimally invasive surgery procedures, one of which is haptic feedback that can mimic the force interaction between the surgical tool and human tissue. Authors further go into detail about utilizing AI to perform surgical tasks under the control of partial or no human guidance under the surgeon's supervision but could eventually lead to full autonomy in the future.
[9] Association of a Remotely Offered Infectious Diseases eConsult Service With Improved Clinical Outcomes.	The authors discussed the benefit of utilizing an electronic consultation (eConsult) or as the article refers to it, asynchronous telemedicine, to avoid logistical issues typical of real-time consult telemedicine such as figuring out the best time for the physician and patient to meet. The study occurred over six months and involved two hospitals. Findings concluded that asynchronous telemedicine could be a viable option to real-time telemedicine.
[10] Developing SMS Content to Promote Papanicolaou Triage Among Women Who Performed HPV Self-collection Test: Qualitative Study.	The study involved five focus groups with a total of 48 female participants located in Argentina to determine the acceptance of patients when utilizing texting or SMS (Short-Messaging Services) to receive the results of their self-collection HPV tests. The study determined that although there was a cost benefit of delivering results via SMS, patients were only receptive of results being ready with delivery of results through the traditional face-to-face, doctor-patient encounter.
[11] District nurses' views on and experiences with a telemedicine educational programme in palliative care.	The article was written on a study conducted in Denmark to implement telemedicine education due to the rise in primary care patients being treated for palliative care. The study involved interviewing four focus groups (three sets of nurses from three municipalities and another interviewing teachers from a specialized palliative care team where topics included those such as acupuncture, shortness of breath, pain, antibiotic treatment, depression, constipation, delirium and grief, loss and pain. It was determined that utilizing inter-professional telemedicine educational programs to teach palliative care to district nurses is beneficial although there were limitations with teachers criticizing the inability to gauge participants' responses to the material, as well as technical difficulties that affected concentration and motivation of the participants.
[12] Telemedicine in postoperative follow-up of STOMa PAtients: a randomized clinical trial (the STOMPA trial).	The article gave some background and advancements of telemedicine. The study followed 110 patients for a 12-month period to obtain insight into the quality of life post-surgical stoma. The article also highlighted the challenges of communication via teleconsultations; however, it did result in decreasing the patient's journey time and overall cost. Those conducting the study noted that teleconsultations could be utilized in most medical specialties - especially those with a high visual component. The also determined that there could be a potential source of bias due to the trial group being the ones who translated the questionnaires.
[13] Feasibility and Accuracy of Tele- Echocardiography, With Examinations by Nurses and Interpretation by an Expert via Telemedicine, in an Outpatient Heart Failure Clinic.	The purpose of the article was to study the feasibility and accuracy of 50 consecutive-focused echocardiography acquired by three registered cardiac nurses and interpreted in near-real time via telemedicine by a cardiologist in Norway. The article discussed the advancements of telemedicine and that the utilization may improve diagnostics and care when distance and available resources matter. Those conducting the study determined that it was both feasible and provided reliable results and could be implemented in remote locations where echocardiography experts may not be available but may improve diagnostics and therapy.
[14] Telehealth delivery of adherence and medication management system improves outcomes in inner- city children	The article followed a six-month study that utilized video-based telehealth (VBT) as a means to deliver better healthcare to children of ages 10 to 17 of minority, low-income families suffering from uncontrolled asthma. As far as the authors were aware, their study was the first study to utilize video-based telehealth in a school setting to improve

with asthma.	the care of asthma in patients of this socio-economic class. The study proved that VBT was a viable intervention tool for various populations in other community settings.
[15] A consolidated model for telepsychology practice.	The article discussed the potential of telepsychology to address current issues in availability, accessibility, acceptability, anonymity, and affordability of mental health services, which is important due to the number of Americans affected by the debilitating effects of mental health problems and their inability to access care. This has resulted in a 28% increase in these patients being treated in emergency rooms for substance abuse and mental health complaints over a 14-year period and mental health care costs that exceed $300 billion per year. The article defined telehealth and provided examples of its use within healthcare. Those conducting the study utilized a scoping review methodology in order to answer the following questions: what guidelines are available for telepsychology practice; how are they similar and different; and how might they be understood together to equip current and future telepsychologists for practice.

Table 1. Continued.

Title	Findings
[16] The Role of North Carolina Medical Schools in Producing Primary Care Physicians for the State.	The article estimated that within the next 10 to 15 years, the U.S. will need approximately 50,000 more primary care providers in order to keep up with the ever-increasing aging population. Some justifications medical students are not pursuing primary care are due to negative perceptions such as the inability to attain higher salaries, as well not being as challenging as other specialties. Although there has been a continual increase in the American population over a 45-year timeframe, the number of generalists has dropped from 58% to 32%.
[17] Scope of telemedicine in neonatology.	The authors began with discussing the widespread shortage of physicians worldwide, especially in rural areas. The authors discussed telemedicine as an alternative, particularly when a patient needs a specialist where the shortage is even more prevalent. The scope of the study was to determine the viability of screening the neonatal population for various ailments that affect premature infants utilizing telemedicine in order to avoid unnecessary transfers to a tertiary care facility , thus reducing the cost of care for this vulnerable population. The authors discussed many advancements in various technologies that when combined with telemedicine, are instrumental in reducing the rural-urban disparity to health care access without compromising quality of care, reducing unnecessary patient transport and allowing more infants to get needed care closer to home.
[18] Eliminating barriers to virtual care: implementing portable medical licensure.	The authors discussed the shortage of physicians worldwide, as well as the growing acceptance of telemedicine by patients who want immediate access to physicians and specialists when served by hospitals in rural and medically underserved areas. There are numerous restrictions and challenges involved in state licensing laws that prohibit providers from practicing via state-to-state and require physicians to acquire and maintain licensure for each state in which they wish to practice medicine, to include telemedicine. The authors argue for moving away from state-based medical licensure and describe policy, technological, and administrative changes necessary for moving toward portable medical licensure. The authors further discuss the Federation of State Medical Boards (FSMB), a national nonprofit organization that represents 70 state medical and osteopathic boards, which has advanced several proposals to enhance license portability, as well as reduce regulatory barriers to telemedicine. The authors also discuss reimbursement incentives for the states through the Department of Health and Human Services.

[19] Impact of nonphysician providers on spatial accessibility to primary care in Iowa. Health Services Research.	The article covered a study to determine how much allowing non-physician providers (advanced practice registered nurses and physician assistants) influence access to primary care in health professional shortage areas in Iowa. Although, Iowa allows non-physician providers to practice as primary care providers, there are still areas where residents are more than 30 minutes from medical provider.
[20] Epidemiology of the 2020 pandemic of COVID- 19 in the state of Georgia: Inadequate critical care resources and impact after 7 weeks of community spread.	Data collected from all 159 counties of the state of Georgia provided a comprehensive look at the COVID-19 epidemiology across the state, to include the vast rural communities that may have been disproportionately impacted by the spread of the virus. The goal of the authors was to present the overall prevalence of confirmedCOVID-19 cases, overall mortality rates attributed toCOVID-19, and the bi-weekly incidence rates of confirmed COVID-19 cases in Georgia. The authors discussed the limitations of the article including the fact that the analysis was conducted with early statistical data and under reporting of all morbidity values due to asymptomatic or slightly asymptomatic cases may not be tested and subsequently diagnosed. The authors further discuss the state of Georgia having limited health care resources, including relatively few intensive care unit beds and active primary care physicians.
[21] Fiber optic deployment challenges and their management in a developing country: A tutorial and case study in Ghana.	Although the article discusses the challenges of telecommunication in Ghana, much of the information applies to its use in rural areas to include the United States. The article discusses the need for high-speed internet connectivity and how fiber optic cable has become the common medium of transmission of providing uninterrupted high-speed internet connectivity to users in both urban and rural areas. Optical fiber delivers communication without degradation of data quality or speed, which the article emphasizes is key to all of the smart equipment that has come online.

The data retrieved from 21 articles connect to categorizing the frequency of occurrence regarding increasing shortage of physicians in the rural United States, which led to the development of five main themes: (a) Telemedicine in rural healthcare; (b) Wearables in healthcare; (c) Artificial Intelligence in rural healthcare (d) Physician shortage in rural areas; and (e) Internet connectivity.

Table 2. *Frequency of occurrence in the literature*

Theme	Occurrences	Instances of Attributes (n)	Percentage (%)
Telemedicine in rural healthcare	[1],[4],[5],[6],[8],[9],[10],[11],[12],[13],[14],[15],[17],[18]	14	67%
Wearables in healthcare	[1],[2],[3],[4],[5],[8],[14],[15]	8	38%
Artificial Intelligence in rural healthcare	[1],[2],[4],[6],[7],[8]	6	29%
Physician shortage in rural areas	[1],[7],[8],[13],[15],[16],[17],[18],[19],[20]	10	48%
Internet connectivity	[1],[2],[4],[5],[8],[9],[12],[13],[14],[15],[17],[18],[21]	13	62%

From the research findings, 67% 14 out of 21 of the articles mentioned theme one, Telemedicine in rural healthcare, which includes articles [1],[4],[5],[6],[8],[9],[10],[11],[12],[13],[14],[15], [17], and [18]. Additionally, the results show, 38% 8 out of 21 of the articles mentioned theme two, Wearables in healthcare, which includes articles [1],[2],[3],[4],[5],[8],[14], and [15]. Also, the findings show, 29% 6 out of 21 of the articles mentioned theme three, Artificial Intelligence in rural healthcare, which includes articles [1],[2],[4],[6],[7], and [8]. From the results, 48% 10 out of 21 of the articles mentioned theme four, Physician shortage in rural areas, which includes articles [1],[7],[8],[13],[15],

[16],[17],[18],[19], and [20]. Finally, the findings show, 62% 13 out of 21 of the articles mentioned theme five, Internet connectivity, which includes articles [1],[2],[4],[5],[8],[9],[12],[13],[14],[15],[17], [18], and [21].

Discussion

Principal Findings. The systematic literature review aimed to determine whether the use of telemedicine, wearables, and AI to supplement increasing physician-staffing shortages in rural areas improve patient-provider connectivity and help sustain patients' residency. A study of 21 peer-reviewed articles published between January and June 2020 allowed for a current analysis of these technologies to supplement the increasing physician-staffing shortages in rural areas by improving patient-provider connectivity, as well as allowing these patients to sustain their rural residency. The data results shown in Table 2 display the main themes that emerged from the analysis of the literature. The five main themes utilized throughout the research included the following: (a) telemedicine in rural healthcare, 1,4-6,8-15,17,&18; (b) wearables in healthcare, 1-5,8,14,&15; (c) AI in rural healthcare, 1,2,4,&6-8; (d) physician shortage in rural areas, 1,7,8,13,&15-20; and (e) internet connectivity, 1,2,4,5,8,9,12-15,17,18, & 21.

Telemedicine proves its viability as an acceptable option to supplement physician-staffing shortages in rural healthcare in order to meet the needs of this underserved population, substantiated by a significant percentage (67%) of the articles in this review [1,4-6,8-15,17&18]. In Norway, a study of 50 consecutive focused echocardiography acquired by three registered cardiac nurses and interpreted in near-real time via telemedicine by a cardiologist proved the feasibility and reliability of utilizing telemedicine in remote locations [13]. The patients' desire for immediate access to physicians and specialists when not physically available due to physician-staffing shortages has overcome past challenges of patient rejection to the use of the technology [18]. The increased usage of telemedicine has become a practical solution for alleviating the shortage of physicians; however, it comes with some issues. One of these issues is that in order for a physician to practice within a state, they must be board certified and licensed in that state, to include telemedicine consults. The interstate licensing and certifications of doctors continues to be a challenge for these providers to practice from one state while the patient is located in another state [18]. While states with large populations may not see this as a problem; states with large rural sections may only have a few specialized physicians in the whole state who just cannot keep up with the demand of their patient population and therefore must rely on out-of-state physicians [18]. In addition to the ability to communicate, as well as be treated surgically [9], with doctors who are located in another facility, or even from their home miles away [17], the utilization of wearables technology is the next evolution to improve patient-provider connectivity and help sustain patients' residency in rural areas.

Wearables allow for a shift of personal responsibility to the patient, as observed in articles [1-5,8,14&15]. While some may argue the onus should rest solely on the healthcare provider, there has slowly been a shift in getting patients involved in their own healthcare; and with the evolution of communication and digital health technologies, this has become more practical and obtainable for the masses [1]. Wearables have proven themselves reliable in studies involving blood pressure readings and electrocardiographs for the diagnosis and treatment of cardiac conditions [5], as well as tracking the person's mood, activity, and sleep patterns [3]. The main issue is getting these technologies into the hands of people with disabilities and those in need of medical rehabilitation, as well as addressing any questions to alleviate any perceptions or anxiety regarding the technologies [2]. The use of real-time data capture integrated into digital health devices combined with Artificial Intelligence could potentially be the key to improving patient adherence, cost effective outpatient services, availability for disabled patients without access to transportation, and the ability to stretch out follow-up appointments.

AI has proven itself to perform standardized practices involved in healthcare in order for medical staff to focus solely on the patient and their treatment, which was noted in articles [1,2,4&6-8]. Surgical robots have been in use for two decades and are automated to routinely perform closing sutures on patients under the supervision of the surgeon. AI could eventually take the place of healthcare workers completely. There have been arguments against this; however, AI has proven its capabilities in replacing approximately 44% of administrative tasks conducted in British studies [7]. Robots have already shown better proficiency and precision in some areas where accuracy and speed are needed in order to maneuver around nerves and vessels. This is especially true with the robot's ability to utilize various imaging technologies, as needed, with only the patient needing to be shielded from radiation [8]. The argument against AI has been the question of teaching a machine empathy, as well as its ability to observe and compensate for the patient's pain [8]. AI could eventually prove to be a worthwhile alternative to the ongoing physician shortage around the world, but gaining acceptance, both from the healthcare providers and the patients, will be one of the biggest hurdles to overcome.

Physician-staffing shortages are being felt throughout the world, most especially in rural communities, which was noted in articles [1,7,8,13&15-20]. One study stated that by 2035, the U.S. will need 50,000 more primary care physicians to keep up with the aging population [16]. Most students in medical school state they are not pursuing primary care due to the inability to attain higher salaries. Many medical schools located in states with higher percentages of rural populations are starting to focus

their students' attention toward a career in primary care by only accepting students from communities within their state [16]. There are practical alternatives to the problem, and many have already been implemented, such as what is currently being done in Iowa. The state allows nonphysician providers (advanced practice registered nurses and physician assistants) to practice as primary care providers in health professional shortage areas [19]. The advancements and studies in telemedicine, wearables, and AI have all proven these technologies to be viable alternatives for face-to-face healthcare. There is, however, a lot of hesitation to pursue these as primary standards of care due to the inability to trust the health of a human to an inanimate object [1]. There are interstate regulations that have become stumbling blocks as well, but it is internet connectivity that has proven to be the biggest hurdle to overcome for all of these to become viable options in rural areas of the United States.

Internet connectivity, to include availability and signal-strength, is the primary key to increasing patient-provider connectivity, as well providing the avenue for patients to sustain their residence in rural areas of the United States. There is a true dependency of telemedicine, wearables, and AI on internet connectivity, which cannot be overlooked if patients and providers will be contemplating taking advantage of these three technologies. Substantiation came from a significant percentage (62%) of the articles in this review [1,2,4,5,8,9,12-15,17,18 & 21]. Fiber optic technology has completely renovated the network infrastructure becoming the only reliable medium for transmission of data without worry of degradation or quality. One single fiber is capable of transmitting more than 3.2 Terabit per second on a single wavelength of color. By combining multiple colors on the single fiber, this pushes the speed to 150 Terabit per second [21]. While for now this extreme is only available in commercial settings, the technology is available and need only be implemented across the country for all citizens to reap the benefits [21].

Limitations. Despite the findings described above, the literature review had some limitations that included the following: (a) the articles only covered the timeframe between January and June of 2020 to limit search engine output; (b) many of the articles had studies conducted in other countries; however, the determination was that they were applicable due to the nature of the question concerning rural areas; (c) the time allotted to conduct the review was only twelve weeks; (d) the author excluded all non-English language articles, which removed certain publications; however, since the question was concerning rural areas of the United States, this was most likely a moot point; and (e) although it was not the intention of the author, the subjective nature of reviewing the articles may have interpreted the information obtained from the articles differently. The systematic literature review involved utilizing Google Scholar as its first preliminary search strategy in order to determine which online database search engines would most likely yield the best results for the study. The author determined that PubMed and Wiley Online Libraries were the best academic database search engines for the study and thus became the secondary search strategy for reviewing the peer-reviewed journal articles. Keywords guided the database searches, thereby possibly omitting some articles that used different terminology while searching through the academic databases.

Minimization of Limitations. The author minimized the limitations listed by following the PRISMA-based systematic review guidelines and protocol [22,23]. The author triangulated and filtered down the information collected, yielding 16,944 articles from PubMed and Wiley Online Libraries, until a data saturation level occurred, and no additional information emerged for developing themes. The author read each article to ensure the articles were in line with the research question, which assisted in minimizing the effect of this limitation. Despite the limitations of the study, the use of telemedicine, wearables, and AI have the potential to supplement the increasing physician-staffing shortages in rural areas by improving patient-provider connectivity, as well as assisting patients to sustain their rural residency.

Future Research. In future studies, the researcher may choose to use these results of the literature review as a stepping-stone for future scholars and researchers conducting a mixed method research design study to help further shed light on the research question. Researchers could also separate each of the three modalities into discrete studies in order to dive further into their respective technological advances. Healthcare leaders could use the findings to validate the need to modernize the internet infrastructure and telemedicine capabilities of their facilities, as well as push their legislators to enact laws to eliminate interstate telemedicine restrictions.

Conclusion

On average, it takes rural residents of the United States over 30-minutes to reach a primary care provider. The purpose of this study was to conduct a systematic literature review to determine whether the use of telemedicine, wearables, and/or AI to supplement the increasing physician-staffing shortages within the rural areas of the United States increase patient-provider connectivity, and help sustain patients' rural residency. The review provided five main themes for patient-provider connectivity and maintaining rural residency. The most common themes include telemedicine in rural healthcare, physician shortage in rural areas, and internet connectivity. The other technologies researched in the study were wearables and Artificial Intelligence. The review identified six challenges involved in the use of telemedicine, wearables, and AI supplementing the increasing physician-staffing shortages in rural areas to improve patient-provider connectivity, as well as assist patients in sustaining their rural residency. The theme most frequently discussed is the inability to trust the health of a human to an inanimate object. Additional themes include inaccessibility to technology for people with disabilities and those in need of medical rehabilitation, interstate licensing, and certification challenges for providers to practice from one state, while their patients are located in another. The final issue was the reliance of the three healthcare technologies (Telemedicine, Wearables, and AI) on internet connectivity, which included availability and signal-strength for these rural areas. Further research can consist of what healthcare organizations are

implementing to assist their patients and staff in overcoming anxiety from utilizing Telemedicine, Wearables, and Artificial Intelligence, as well as getting the technologies into the hands of their patients without incurring personal costs to promote patient-adherence. The implications of these findings provide healthcare leaders ample justification for ensuring their treatment facility has access to a modern internet infrastructure and the latest in telemedicine technology, as well as to push their legislators to enact laws to eliminate interstate telemedicine restrictions.

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