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EDITORIAL REVIEW BOARD

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DATA-DRIVEN CURRICULUM DEVELOPMENT: USING PUBLICLY AVAILABLE DATA TO IDENTIFY THE WORKFORCE NEEDS FOR UNDERGRADUATE BUSINESS STUDENTS

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ABSTRACT

Assuring the alignment of business education with labor market needs is crucial for preparing graduates with the necessary skills for their future careers. Combining data from the U. S. Census Bureau's American Community Survey and the U. S. Department of Labor's Occupational Information Network, this paper examines the occupational outcomes and required skills of jobs most commonly held by undergraduate business majors. Significant diversity in occupational outcomes for undergraduate business graduates exists, which suggests a need for a curriculum providing a broad range of skills. Additionally, by utilizing data from occupational analysts on the skills required in jobs and supplementing these data with information about in-demand technology skills from real-world job postings, stakeholders in colleges of business can ensure their curriculum is aligned with the current needs of the labor market.

Keywords: *business curriculum, skill requirements, O*NET, occupational outcomes*

INTRODUCTION

According to several polls, students' primary motivation for attending institutions of higher education in the United States is to improve their job prospects (Higher Education Research Institute, 2012; Strada Education Network & Gallup, 2018). Several states have developed explicit goals with regard to the skills of graduates of state institutions of higher education. (Colorado Department of Higher Education, 2021; Texas Higher Education Coordinating Board, 2015). For example, one goal of the Texas Higher Education Coordinating Board's current strategic plan is "by 2030, all graduates from Texas public institutions of higher education will have completed programs with identified marketable skills" (Texas Higher Education Coordinating Board, 2015, p. 22). This plan requires state institutions to define and assess marketable skills for each of their program offerings.

Additionally, some accrediting bodies emphasize the importance of aligning curriculum with labor market needs. The Association to Advance Collegiate Schools of Business (AACSB) standards require that accredited business schools align their curriculum with the relevant skills in the workforce, including the use of appropriate technologies used in the business environment (AACSB International, 2020). Students, policy makers, and business accrediting bodies demand curriculum that is current, relevant, and aligned with workforce needs. This alignment is complicated by an ever-changing job market, as well as advances in technology that fundamentally change job tasks and the required skills of workers. However, there are several methods by which institutions can ensure that their offerings meet the needs of employers, prospective students, accrediting bodies, and state legislatures. This paper provides a method for stakeholders of colleges of business to use publicly available data to help ensure their curriculum prepares graduates with the in-demand skills required in the current and future labor market.

LITERATURE REVIEW

Education in business has evolved substantially in the United States over the past several centuries. At first, training in commerce was conducted using an apprenticeship system; later private business schools offered coursework in vocational skills useful in business (Applegate, 2022). Even later, traditional colleges and universities began to offer a business education, in a move that attempted to shift the focus away from purely vocational training towards a more comprehensive college education (Khurana, 2010). Founded in 1881, the Wharton School claims to be the world's first collegiate business school, with a foundational goal of preparing graduates with the knowledge to become "pillars of the State, whether in private or in public life" (University of Pennsylvania, n.d.).

Curriculum in colleges of business has changed over time, as the labor market itself has transformed. Much has been written by economists about the many ways new technologies have impacted the labor market (Acemoglu & Autor, 2011; Damelang & Otto, 2024; Hötte et al., 2023). One theme from this literature is the idea that new technologies replace human labor for certain tasks, while increasing the productivity of workers in other functions, therefore increasing the demand for these activities (Acemoglu & Restrepo, 2019; Autor, 2015). For example, the accounting profession has undergone substantial changes since the widespread adoption of the personal computer, and future technologies including artificial intelligence are forecasted to further change the nature of accounting jobs. (Cunha et al., 2022; Moll & Yigitbasioglu, 2019; Kee, 1993). Of course, accounting jobs have not been eliminated due to the adoption of new technologies including the widespread adoption of personal computers and spreadsheet software. Rather, the nature of the tasks of a typical accountant have changed and will continue to change in the future, due to new and unforeseen innovations. If colleges of business want to continue to provide current and relevant training, the curriculum will need to adapt to an ever-changing world.

For decades, some researchers have been critical of the relevance of business school training (Leavitt, 1989; Pfeffer & Fong, 2002). When implementing a curriculum that provides an occupationally relevant education, one obviously would need to identify the related target occupations of graduates. Research suggests that student major selection is often related to student occupational goals, even though many programs are not explicitly aligned with one specific job (Patnaik et al., 2020). Although some undergraduate majors like nursing or elementary education tend to lead to employment in a specific occupation, most college program offerings lead to at least some occupational diversity (Ransom & Phipps, 2017). This diversity can add complexity to curriculum development, in that undergraduate program offerings do not typically align with exactly one job. While engineering, nursing, and education majors tend to have high occupational distinctiveness, business majors typically display more variety in occupational outcomes, with the exception of accounting programs. (Ransom & Phipps, 2017).

Institutions of higher education can individually track their graduates and collect occupational information in order to understand the types of jobs their graduates hold. Often this approach can suffer from problems of selection bias, as not all students will respond to alumni surveys, or maintain LinkedIn or other social media profiles that can be tracked. As an alternative, the Bureau of Labor Statistics (BLS) and the National Center for Educational Statistics (NCES) jointly created a crosswalk between Standard Occupational Classification (SOC) and Classification of Instructional Programs (CIP), in order to link college program offerings to related occupations. This crosswalk is most useful for educational program and workforce alignment where degrees and occupations are closely aligned with one another (Goldman et al., 2015).

For most occupations there is typically more than one related program listed. For example, for the SOC for human resource managers, six separate CIP programs are listed as related to that one occupation. Most CIP programs also list multiple occupations in the crosswalk, as graduates of programs feed into multiple jobs. Although this linkage from jobs to degrees can be useful, it also does not provide any indication of the proportion of graduates that are hired into each occupation.

An alternative is to consider the business curriculum as a whole, rather than these more disaggregated CIP codes. David et al. (2011) conducted a content analysis of corporate job descriptions, student résumés, business course syllabi, and textbooks to examine the alignment of curriculum with entry-level jobs for undergraduate business majors. Using a sample of 200 entry-level job postings, 100 syllabi, and a sample of student résumés from five universities, the authors argue that there is a substantial gap between what is taught in colleges of business and the skills sought by companies. Specifically, they argue business colleges should revise their missions to become more practitioner-oriented, and shift the curriculum away from a focus on theory and more towards practice. The authors do note that their study may not be representative of colleges of business overall, as the data only came from five universities. (David et al., 2011).

Other evidence suggests the continued value of broad higher-order thinking skills in the labor market, and that schools are correct in focusing on these types of skills. A survey developed by the American Association of Colleges and Universities and administered to a sample of 1010 employers in May 2023 found that eight in ten employers either weakly or strongly agreed that higher education institutions were preparing graduates to success in the workforce (Finley, 2023). The survey did identify several gaps in employers' perceptions of certain skills, with weaknesses identified in oral and written communication, critical thinking, and adaptability and flexibility of recent graduates (Finley, 2023). Other surveys corroborate the value to employers of broad skills such as problem-solving, communication, and flexibility (National Associate of Colleges and Employers, n.d.).

APPROACH AND DATA

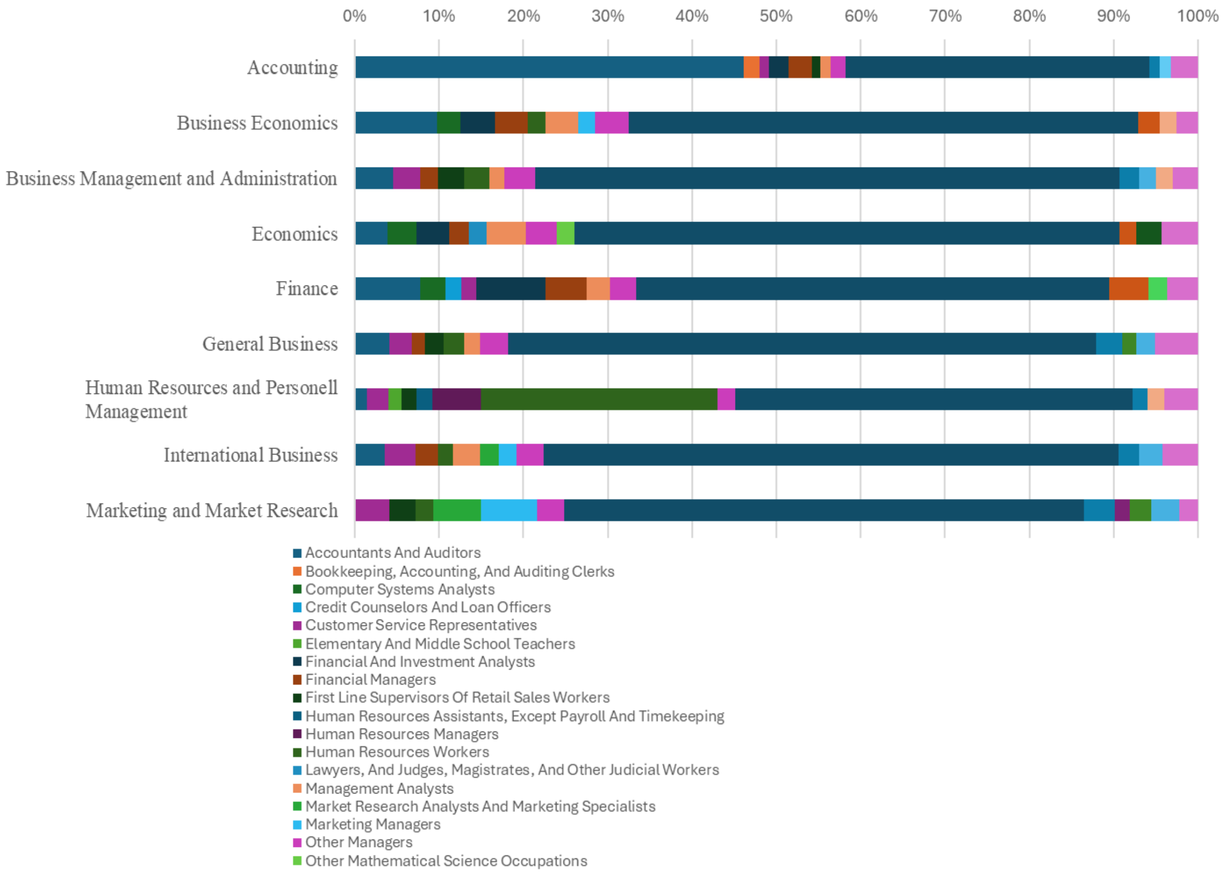
American Community Survey

Rather than using data on graduates' employment history for a particular institution of higher education or the federal government's SOC to CIP crosswalk of programs to jobs, one can combine several sources of publicly available data to help understand the labor market needs associated with particular undergraduate business majors. These data can be used either as a stand-alone measure of the skills required for particular degrees, or to supplement other sources in curricular development and assessment. This process involves first linking undergraduate business programs to jobs, and then collecting information about the skills required within these particular occupations. First, data were extracted from the U. S. Census Bureau's American

Community Survey (ACS). The survey asks a variety of social, demographic, educational, and economic questions of members of approximately 3. 5 million households annually (United States Census Bureau, 2023). Since 2009, the ACS has inquired about field of study for those respondents who report having earned a bachelor's degree or higher. This question allows for the linkage of college major to employment information. Specifically, one can link college majors of survey respondents to specific Census Bureau occupations that are also collected in the ACS.

Figure 1

Most Commonly Held Jobs for Select Undergraduate Business Programs (5-year ACS, respondents 30 Years or Younger)



In order to isolate occupations of recent graduates, data from the most recent five-year ACS public use microdata sample was used, with information extracted on occupation and field of degree for individuals who report being 30 years old or younger. This age restriction exists so that the sample is restricted to relatively recent graduates, as the educational requirements of occupations has been noted to have changed over time (Goldman et al., 2015). In other words, a worker decades ago may have not needed a bachelor's degree to gain entry to certain occupations, whereas there is now an expectation that new employees hold a four-year degree. It is also possible that certain majors once provided entry to a particular occupation, but recent graduates are expected to have degrees in other specific degree programs. It should be noted that the ACS asks about the first bachelor's degree, so the occupational data are only linked to the first degree earned, and workers may have more than one undergraduate degree and may also hold advanced degrees.

Figure 1 provides a visualization of the ten most common occupations held by graduates of nine of the most commonly offered business degrees, using the most recently available 5-year ACS data. Not all business majors are listed in this figure, and the Census Bureau does collect information for additional degrees in programs such as agribusiness, actuarial science, logistics, management information systems, and heath care management if stakeholders want to understand the labor market needs associated with occupations related to these additional majors. Both economics and business economics are included in Figure 1 as some colleges make distinctions between these degrees and may offer one or both of the programs. As an additional aside, the Census Bureau uses its own occupational code system, but provides a crosswalk to SOC codes, so that jobs can be linked to other commonly used data sources. Several patterns emerge from the data in Figure 1. First, as expected a few programs more carefully align with one or two specific jobs, whereas other programs have substantially more occupational diversity. For example, more than 46 percent of respondents with a first bachelor's degree in accounting report working as an accountant or auditor in the ACS. Likewise, almost 36 percent of survey respondents with human resource and personnel management degrees report being employed as either human resource managers, workers, or assistants. Even among graduates of these two business majors, there is substantial occupational diversity; a majority of graduates in these programs do not report working as accounting or human resource professionals, respectively. Other business majors listed demonstrate even more occupational diversity. Almost 70 percent of general business majors work in occupations other than the ten most commonly listed. These data reenforce the idea that business schools may wish to provide programs with a curriculum that focuses on skills outside of the most obviously linked occupation for each major.

Occupation Skills Data

Using occupational code crosswalks, occupational data from the ACS can be linked to other data sources that provide information about the skills required in various jobs. The U. S. Department of Labor's Office of Policy and Research developed the Occupational Information Network (O*NET) in the late 1990s in order to replace the previously used Dictionary of Occupational Titles. (Rounds et al., 1999). O*NET provides a variety of information about occupations, including the required knowledge, skills education, experience, training, and tasks required for each job. The database was developed to help support individuals in making career and educational decisions as well as to aid policymakers and researchers in their study of labor markets. O*NET data is mostly available for jobs that have associated SOC codes from the BLS, although there are some exceptions as noted later in this paper. O*NET also provides a comprehensive list of real-world job titles, which can be particularly useful in linking the government occupational codes to real-world job advertisements. Crucially, O*NET is continually updated to provide information about the skills, educational requirements, and tasks that typically exist for each occupation.

Among other items, O*NET contains occupation-specific information about required jobs skills, including broad skills that are deemed essential to a variety of jobs. At their most general, the O*NET skills are categorized into seven broad groups of skills: content, process, social, complex problem-solving, technical system, and resource management skills (Fleisher & Tsacoumis, 2012). These skills are further disaggregated into 35 separate job skills within the aforementioned seven broad categories. For example, social skills include the sub-skills of social perceptiveness, coordination, persuasion, negotiation, instructing, and service orientation (Fleisher & Tsacoumis, 2012). Eight occupational analysts rate both the importance and level of each of the 35 skills for each O*NET occupation (Burgoyne et al., 2021). Importance measures how critical the skill is for successfully performing a particular job, while level refers to the degree of proficiency a worker needs in that skill or that particular occupation. As an example, 'speaking' is defined in O*NET as talking to others to convey information effectively, and is a sub-skill of the broad 'content' skill category. (United States Department of Labor Employment and Training Administration, n.d.) Speaking is rated as an important skill for both lawyers and paralegals, but occupational analysts rate the level of speaking required as higher for lawyers as compared to paralegals. Although both jobs require the ability to verbally convey information effectively to judges, clients, and juries, occupational analysts only rate the level of speaking skill required as average for paralegals, while they assess that lawyer must be able to speak effectively at a very high level. To complicate matters, importance is rated by analysts on a scale of 1-5, while level is assessed using a 0-7 scale. O*NET documentation provides a method for converting these separate ratings into a standardized score on a 100-point scale, in order to make the ratings more comprehensible to users (United States Department of Labor Employment and Training Administration, n.d.). As an example, analysts rate the importance of mathematics skills at 100 for mathematicians on this standardized scale, while they rate mathematical skill as 0 in importance for actors.

In recent updates, O*NET also provides a list of in-demand technology skills, which are software or technology requirements that are frequently included in employer job postings online (Lewis & Morris, 2022). The Department of Labor partnered with Burning Glass Technologies, now called Lightcast, in order to collect information web-scraped from online job postings. Although Lightcast is a proprietary data source, annual information about these in-demand skills is made publicly available in the O*NET database, along with other related information for each occupation. In-demand technology skills are defined as technology and software identified by O*NET that appear in more than five percent of all unique, unduplicated online job postings for that occupation during a calendar year. In this case, the most recent data from 2023 are utilized. Occupations with fewer than 50 unique occupations are omitted from inclusion in these data (Lewis & Morris, 2022).

Table 1
Most Common Occupations for Graduates of Business Programs (Respondents 30 Years or Younger from 5-year ACS)

ACS Occupation Title	**Frequency Listed in Programs**	**Exact Match (O*NET)**	**Sample of Reported Job Titles**
Other Managers	9	no	This category represents jobs with characteristics which do not fit into one of the O*NET-SOC occupations
Accountants And Auditors	8	yes	Accountant, Auditor, Certified Public Accountant, Cost Accountant, Financial Auditor, Internal Auditor
Financial Managers	7	yes	Accounting Supervisor, Branch Manager, Business Banking Manager, Credit Manager, Financial Planning Manager
Management Analysts	7	yes	Business Analyst, Business Consultant, Management Analyst, Management Consultant
Customer Service Representatives	7	yes	Account Representative, Client Services Representative, Customer Care Representative, Customer Service Agent,
Human Resources Workers	6	yes	Corporate Recruiter, Employment Representative, HR Analyst, HR Coordinator HR Generalist
Retail Salespersons	6	yes	Customer Assistant, Retail Salesperson, Sales Associate, Sales Consultant, Sales Representative
First Line Supervisors of Retail Sales Workers	5	yes	Department Manager, Department Supervisor, Shift Manager, Store Manager
Financial And Investment Analysts	4	no	Analyst, Credit Products Officer, Financial Analyst, Investment Analyst, Portfolio Manager, Securities Analyst, Trust Officer
Sales Representatives, Wholesale and Manufacturing	4	no	Inside Sales Representative, Marketing Representative, Sales Representative
Marketing Managers	3	yes	Account Supervisor, Brand Manager Marketing Coordinator, Marketing Director, Marketing Manager, Product Manager
Personal Financial Advisors	3	yes	Certified Financial Planner (CFP), Financial Advisor, Financial Counselor, Financial Planner, Portfolio Manager, Wealth Advisor
Computer Systems Analysts	3	yes	Applications Analyst, Business Systems Analyst, Computer Systems Analyst, Computer Systems Consultant
Secretaries And Administrative Assistants, Except Legal, Medical, And Executive	3	yes	Administrative Assistant, Administrative Specialist, Office Assistant, Secretary, Staff Assistant
Market Research Analysts and Marketing Specialists	2	yes	Business Development Specialist, Communications Specialist, Market Analyst, Market Research Analyst, Market Research Consultant, Market Research Specialist, Market Researcher
Sales Managers	2	yes	District Sales Manager, Regional Sales Manager, Sales and Marketing Vice President (Sales Director, Sales Manager,

RESULTS

Broad Occupational Skills

Table 1 provides more detail about the specific occupations held by graduates of business programs. Specifically, the table shows the frequency with which occupations are listed in the top ten occupations of each of the nine selected business programs, for workers 30 years of age or younger. Only the Census Bureau occupation 'other managers' makes the top ten occupations for each of the nine selected majors, although there is substantial overlap across various business programs. 'Accountants or auditors' ranks among the top ten most commonly reported occupations held by younger workers in eight of the nine programs, for example. Table 1 also includes a sample of reported job titles from O*NET, which can help provide some real-world context for the specific occupational categories. Not all ACS occupations align perfectly with the O*NET data. 'Other managers' include a wide range of jobs that have little in common in terms of skills and tasks, while 'financial and investment analysts' and 'sales representatives, wholesale and manufacturing' include multiple occupations in O*NET and cannot be linked directly to a specific O*NET occupational skillset. Therefore, these three ACS occupations will be excluded from further analysis. In order to understand the required skills of business graduates as a whole rather than a particular major, any occupation only in the top ten most common jobs for exactly one major are also excluded. Therefore, there are 13 occupations remaining that were chosen to be linked to O*NET skills. These 13 occupations are denoted with a 'yes' in the third column of Table 1 and will be the target group of jobs for the analysis of broad skills for business majors.

Table 2 provides a summary of the skills in O*NET associated with these 13 occupations, as assessed by occupational analysts in the Department of Labor. The ratings for importance of and level are standardized to a 100-point scale, and the skills are sorted by the number of the common occupations rated as requiring at least average importance of the particular skill. Table 2 only includes 27 of the 35 broad skills, as eight of the skills are not rated as of at least average importance in any of the 13 target occupations. These include skills such as equipment maintenance, repairing, and management of material resources, among others that are typically not required of occupations held by typical business graduates. Eight skills are assessed as at least of average importance in all 13 occupations: active listening, critical thinking, monitoring, reading comprehension, social perceptiveness, speaking, time management, and writing. The O*NET data provides evidence that these broad skills are the most important for jobs that are typically held by younger business graduates.

Many of the skills listed in Table 2 are similar to common learning goals of undergraduate business programs. While accrediting bodies are often loathe to specify exactly what skills higher education institutions should target, there is some commonality across institutions in selecting learning goals, and several of those common goals align with the skills listed in Table 2. Woodside (2020) conducted a meta-analysis of undergraduate learning goals across AACSB accredited business schools and found substantial commonality across institutions. Woodside found written communication, oral communication, application of knowledge, and ethical understanding and reasoning to be the most common learning goals.

Teamwork, global knowledge, critical thinking, analytical thinking, evidence-based decision making, and the ability to solve problems were also common learning goals listed in the meta-analysis (Woodside, 2020). Of the eight broad skills identified in all of the related occupations, several seem to be aligned with common learning goals of business schools. Speaking and writing skills are directly linked to oral and written communication. Social perceptiveness is defined as being aware of others' reactions and understanding why they react as they do, which may be part of working effectively in teams, for example. (Fleisher & Tsacoumis, 2012).

Active listening, monitoring, and time management do not commonly appear as learning goals among AASCB accredited institutions, and potential could be areas where programs could find opportunities to strengthen the skills of the graduates. Of course, it is also possible that programs may already provide training in these skill areas even if they are not explicit goals incorporated into formal assessment documentation. Negotiation and persuasion are also rated as above average in importance in 10 of the 13 target occupations. In terms of the level of the skill required, only active listening was rated as above average in each of the 13 occupations. Stakeholders can find definitions of each of these broad skills in O*NET documentation (Fleisher & Tsacoumis, 2012).

Table 2

Importance and Level of Skills Required for Most Common Occupations of Business Majors (Respondents 30 Years or Younger from 5-year ACS)

	Importance				**Level**			
	Sum	**Mean**	**Max**	**Min**	**Sum**	**Mean**	**Max**	**Min**
Active Listening	13	73	78	69	13	57	63	52
Critical Thinking	13	68	78	50	12	56	61	45
Monitoring	13	59	72	50	10	54	68	43
Reading Comprehension	13	69	78	50	11	57	66	45
Social Perceptiveness	13	61	72	50	7	50	59	43
Speaking	13	73	78	69	12	56	59	45
Time Management	13	56	66	50	4	47	55	41
Writing	13	64	75	50	11	53	59	43
Coordination	12	57	72	47	6	48	59	41
Service Orientation	12	61	75	47	6	49	55	41
Active Learning	11	58	72	47	7	51	59	41
Complex Problem Solving	11	60	75	44	9	50	57	36
Judgment and Decision Making	11	61	75	47	9	51	59	37
Negotiation	10	52	72	35	5	46	55	30
Persuasion	10	57	78	31	7	50	63	30
Systems Analysis	9	50	69	25	7	45	57	27
Learning Strategies	8	47	56	28	4	44	54	27
Systems Evaluation	8	49	72	25	5	45	59	25
Mathematics	7	47	67	25	3	43	57	23
Instructing	6	49	66	28	5	46	52	34
Management of Personnel Resources	5	48	69	31	4	43	57	30

Management of Financial Resources	3	33	53	10	3	32	54	7
Operations Analysis	3	34	60	6	3	31	55	4
Operations Monitoring	1	23	50	13	0	20	45	7
Programming	1	21	56	6	1	18	57	4
Quality Control Analysis	1	22	50	3	1	19	50	2
Troubleshooting	1	7	53	0	1	7	55	0

Table 3
*In-demand Technology Skills for Most Common Occupations of Business Majors (O*NET and Lightcast Data)*

	Technology	**Example Technology**
Accountants and Auditors	Spreadsheet software Office suite software Electronic mail software Presentation software	Microsoft Excel Microsoft Office software Microsoft Outlook Microsoft PowerPoint
Computer Systems Analysts	Content workflow software Web platform development software Spreadsheet software Office suite software Presentation software Object-oriented development software Enterprise resource planning ERP software Data base user interface and query software	Atlassian JIRA JavaScript Microsoft Excel Microsoft Office software Microsoft PowerPoint Oracle Java and Python SAP software Structured query language SQL
Customer Service Representatives	Spreadsheet software Office suite software Electronic mail software	Microsoft Excel Microsoft Office software Microsoft Outlook
Financial Managers	Spreadsheet software Office suite software Electronic mail software Presentation software	Microsoft Excel Microsoft Office software Microsoft Outlook Microsoft PowerPoint
First-Line Supervisors of Retail Sales Workers	Office suite software	Microsoft Office software
Human Resources Managers	Spreadsheet software Office suite software Electronic mail software Presentation software	Microsoft Excel Microsoft Office software Microsoft Outlook Microsoft PowerPoint
Management Analysts	Spreadsheet software Office suite software Presentation software Process mapping and design software Database user interface and query software	Microsoft Excel Microsoft Office software Microsoft PowerPoint Microsoft Visio Structured query language SQL
Market Research Analysts and Marketing Specialists	Graphics or photo imaging software Data mining software Spreadsheet software Office suite software Electronic mail software Presentation software Customer relationship management software Video creation and editing software	Adobe Photoshop Google Analytics Microsoft Excel Microsoft Office software Microsoft Outlook Microsoft PowerPoint Salesforce software TikTok
Marketing Managers	Spreadsheet software Office suite software	Microsoft Excel Microsoft Office software

	Presentation software Customer relationship management software	Microsoft PowerPoint Salesforce software
Personal Financial Advisors	Spreadsheet software Office suite software Presentation software	Microsoft Excel Microsoft Office software Microsoft PowerPoint
Sales Managers	Spreadsheet software Office suite software Electronic mail software Presentation software Customer relationship management software	Microsoft Excel Microsoft Office software Microsoft Outlook Microsoft PowerPoint Salesforce software
Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	Spreadsheet software Office suite software Electronic mail software Presentation software Word processing software	Microsoft Excel Microsoft Office software Microsoft Outlook Microsoft PowerPoint Microsoft Word

In-demand Technology and Software

As with broad skills, the focus of analysis will be on the most commonly held jobs of younger business graduates. As previously mentioned, data on in-demand technologies are drawn from real-world job postings from Lightcast for the 2023 calendar year. Of the 13 previously described commonly held occupations, all have at least one identified in-demand technology or software skill, except for retail salespersons. Although this occupation is commonly held by younger business graduates, the BLS notes that no formal educational credential is required to become a retail salesperson, and this may not be a job that business schools target for their graduates (Bureau of Labor Statistics, U. S. Department of Labor, 2023). Table 3 provides a summary of the in-demand technology and software for the remaining 12 target occupations. The skills are presented as reported by O*NET, although there is some overlap in some of the in-demand skills. For example, all 12 occupations list office suite software as in-demand, while some job postings also reference software itself typically included in an office suite software program such as e-mail, word processing, presentation software, and spreadsheets. In fact, spreadsheet software is listed separately in 11 of the occupations as in-demand, while presentation software is listed separately for 10 of the jobs. Although it may seem obvious that workers need to be able to use office suite software in their jobs, not all occupations have job postings referencing these technologies. Of the 923 separate occupations where data is collected by O*NET on in-demand technology, only 347 occupations list office suite software as an in-demand technology; that number is reduced to 316 and 163 for spreadsheet and presentation software, respectively. However, for the types of jobs that business graduates hold, these basic software skills seem to be in high demand.

Beyond basic office suite technologies, the list of occupations in Table 3 differ somewhat in terms of software skills that are currently rated as in-demand. Customer relationship management software was rated as in-demand for jobs in marketing and sales, whereas Structure Query Language (SQL) appeared in a substantial number of job postings for both management and computer systems analysts. Not surprisingly, computer systems analyst job advertisements also reference various programming languages such as Python, Java, and JavaScript.

CONCLUSION

The analysis of data from ACS and O*NET provide several key stylized facts. First, business graduates exhibit significant occupational diversity, with graduates finding employment in roles that require a variety of general skills. Second, many of the identified broad skills are already targeted by the learning goals of AACSB institutions, which is a sign that accredited colleges of business are at least somewhat aligned with the workforce needs of relevant occupations for early career business graduates. However, some broad skills such as active listening, monitoring, coordination, and persuasion are not as commonly represented in typical learning goals. These may be areas where there are opportunities for curricular changes to better equip students with the skills needed to be successful in their future careers. It is also possible that students are already inculcated with these skills and that institutions simply need to find ways to demonstrate their students' mastery of skills. For example, institutions could consider skills badging or certificates associated with particular skills.

In terms of technology skills, the data from job advertisements from 2023 demonstrate that early career business occupations most common in-demand technology skill is the use of spreadsheets and presentation software. These skills show up across the occupational spectrum for common jobs of younger business graduates. For certain types of analyst occupations, other types of software skills are in-demand, including customer relationship management software, SQL, and programing languages for computer system analysts. Although the job advertisement data is collected from a proprietary data source, O*NET provides a publicly available way to observe these in-demand technology skills on an annual basis, by occupation. This information can be particularly useful in ensuring that curriculum is current and relevant, in a rapidly changing business environment.

In terms of future research, there are several avenues worthy of further exploration. First, this paper has exclusively focused on the occupations held and skills required for business majors. It would be useful to conduct a similar analysis of the occupations held by graduates of traditional liberal arts programs, especially in a time of declining enrollment in these programs. A better understanding of the jobs most commonly held by recent graduates of non-business programs and the required skills associated with these jobs would make it possible to add explicit vocational elements to these degrees. As previously mentioned, this will be particularly important given the primary motivation students report for attending institutions of higher education. Second, the recent emergence of new technologies related to artificial intelligence promises to change the workplace in the next few decades. Will firms demand that all college graduates be fluent in the use of these new machine learning technologies, or will these tools be isolated to a handful of programs and related occupations? Artificial intelligence skills do not appear in the most recent data as described in this paper, but stakeholders will want to track the use of these technologies in order to maintain the currency and relevance of their programs. Finally, the focus of this paper was on the skills associated with occupations of relatively recent graduates. One could also conduct a similar analysis for older graduates of business programs, to understand the skill requirements for mid-career workers. This analysis would be particularly useful for institutions offering masters or graduate certificates, to ensure that their offerings are relevant to the labor market needs for their graduates.

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NEW FRONTIERS IN SERVICES: A TASK-ORIENTED CLASSIFICATION OF SERVICE ROBOTS

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ABSTRACT

During the past few years, the service industry has been hit by a wave of automation, technology, and artificial intelligence. Robots that traditionally were used in the manufacturing industry started to move into dynamic human environments, assisting humans in work and private lives (Chuah, Aw & Yee, 2021; Nelson, 2017). The need for innovation, labor shortages, and the isolation imposed after COVID-19 have driven the use of emerging technologies that lead to the visualization of service robots as support or substitute for humans in situations such as providing services. services (Bowen & Morosan 2018; Wirtz, Kunz & Paluch 2021). This market development brings a unique opportunity for entrepreneurs to enter untapped markets.

The service industry is relatively broad, and robots have been well received so far, especially for repetitive tasks such as checking guests in hotels, providing information at airports, serving in restaurants or hospitals, and even entertaining customers (Tuomi et al., 2021). The combination of technology and artificial intelligence has allowed service robots to go from performing repetitive tasks to performing simple and complex tasks based on three basic skills essential for dealing with customers. As technology development speeds up, entrepreneurs must comprehend customers' and employees' expectations and perceptions in various service encounters in order to develop well-accepted robots.

To better understand service robots and to provide a common language within the entire domain, this study summarizes and proposes a table with different types of robots, including their definitions, possible classification labels, and examples (Nassiraei & Ishii, 2007; Huang & Rust, 2021; Vujovic et al., 2017). It also proposes a classification model for task-oriented physical robots based on three skills, social/emotional, cognitive/analytical, and physical, for performing simple and complex tasks during service deliveries.

KEYWORDS: *Service robots, artificial intelligence, customer satisfaction, task-oriented classification.*

INTRODUCTION

Humanity has experienced the birth of various technological inventions that have changed lifestyles. They have gone from horse-drawn cars, steamboats, and railways to electric vehicles, motorboats, and subway lines, from telegraphs and physical letters to mobile devices and emails. The appearance of steam engines and the use of electrical energy transformed society and strongly impacted the economy, quadrupling the world's per capita income with the industrial revolution (Sorooshian & Panigrahi, 2020; Bloem et al., 2014). Industry played a vital role in the economy of the time, producing highly mechanized and automated material products. The manufacturing sectors, together with agriculture and textiles, were the most impacted, as technology made possible mass production and the division of labor through the use of the conveyor belt and the assembly line (Sorooshian & Panigrahi, 2020; Duarte et al., 2018). The implementation of technology in production prompted companies worldwide to constantly upgrade and automate their production processes to stay competitive in their fields.

Consumers live in an era of dizzying changes where the constant appearance of new technologies such as big data, the internet of things, artificial Intelligence (AI), and 5G communication have forced us to continually reinvent the way we live, especially organizations due to its remarkable dynamism and competitive field of business (Sheng et al., 2021). Technologies are getting smarter and more powerful, offering the possibility of quick machine setup and more efficient production processes. The use of lighter materials also makes them cheaper and driven by AI; they have become more desirable and adaptable to customer requirements, improving customer experience and quality of service in the service industry (Paluch & Wirtz, 2020). Some organizations have already started innovating AI alongside physical robots to take their service to another level, like Amazon's Prime Air, which uses drones to automate shipping and delivery. Domino's Pizza is experimenting with self-driving cars and delivery robots, and RedBalloon is using Albert's AI marketing platform to discover and reach new customers (Huang & Rust, 2021).

Factors like COVID-19 are accelerating innovation and change in the service field, encouraging the use of virtual reality and remote work in education. Even in health services, for instance, the demand for medical service robots that check people's temperature or take over disinfection work has increased during the last months, all due to the social distancing and nonphysical contact that has been imposed (Wirtz et al., 2021). The pandemic led to the visualization of service robots as supports or substitutes for humans in service encounters. The combination of technology and human capabilities can effectively improve service encounters, especially when used to perform tasks relatively simple and repetitively related to customer-facing. These repetitive tasks include "taking orders, dealing with payments, providing more product information, managing restaurant queues, and performing hotel customer check-ins" (Tuomi et al., 2021, p. 237).

Robots have moved from the industrial sector into dynamic human environments, increasingly supporting humans both at work and in their private lives, becoming service robots. The global service robotics market is growing at an annual compounded growth rate of 22.6% and is projected to increase from USD 37 billion in 2020 to USD 102.5 billion by 2025 (Chuah et al., 2021). This growth is due to factors such as positive profitability, improved resource utilization, demand forecast accuracy, quality control, process management, and disposal of human errors (Ivanov et al., 2017). In particular, recent years have seen rapid development in service robots for the hospitality industry, robots that cook complex meals, and robots that serve customers in hotels or airports. Bowen and Morosan (2018) believe that the main reason for the increase of robots in most industries is the labor shortage, which has pushed the use of emerging technologies to fill the need.

Japan, a pioneer country in the implementation of service robots, was forced to include service robots in hotels due to the increase in the proportion of elderly people, the drop in the birth rate, strict immigration policies, the expected significant growth of the demand for services, and the decrease in costs since robotic labor being usually less expensive than human labor. Henn-na Hotel was the first hotel in Japan to employ robots in all its operations without human intervention, from check-in at the front desk to automated bag drop, since 2015 (Tussyadiah & Park, 2018). Hotel robotics implementations are often integrated with other AI technologies, such as facial recognition, automatic checkout, and self-driving cars, to improve the experience. The success of service robots depends on the satisfaction of users. Some characteristics of robots induce positive reactions in consumers, for example, their level of anthropomorphism or the complexity level of cognitive/analytical tasks they perform (Wirtz et al., 2021; Tussyadiah & Park, 2018). Previous studies (Jia et al., 2021; Chuah et al., 2021; Park & del Pobil, 2013) indicate that human appearance induces positive perceptions and attitudes in consumers, so humans may judge humanoid robots favorably in terms of appearance and similarity with sociability required to perform complex tasks (Belanche et al., 2020).

The fast-paced development of service robots and frequent failure incidents led us to the research problem. There is a need for an organized effort in research and development. Moreover, these efforts should reflect the human element's expectations, both customers and employees. A classification framework will enable developers, policymakers, and academicians who wish to investigate human-robot interactions.

The service industry is relatively vast, as are the different robots that can be used in this industry, such as in hotels, airports, restaurants, hospitals, and even deliveries (Wirtz et al., 2021). Classifying them to better understand their similarities, differences, and possible combinations is necessary based on service robots' abilities and the complexity of the tasks they can perform. The abilities of service robots involve their social/emotional, cognitive/analytical, and physical skills. Thus, classification is necessary to understand the phenomenon as it provides a common language within the entire domain of service encounters (Lambert 2015)**.** This research aims to propose a classification of robots in the service industry based on three main characteristics and abilities, as well as the level of task development. This classification may help academic researchers develop theories about human-robot interactions, practitioners identify design specifications, and policymakers conceptualize regulations. Our research objective is to review the theoretical and practitioner literature to explore the phenomenon as it is occurring and organize the knowledge around a framework.

LITERATURE REVIEW

Technological transformation has been evidenced since the Industrial Revolution at the end of the 18th century. Humanity has experienced different scientific-technological innovations such as steam engines, electric power, production lines in the manufacturing industry, and transformations in the service industry with transitions from full personal service to self-service technology (Bloem et al., 2014; Anitsal et al., 2002). The economic benefits of technological innovations were evident. Since the beginning of the 19th century, the income per capita grew at an average of 0.9 percent per year, eight times faster than the growth before the Industrial Revolution. The era of constant economic growth began when consumers got used to constantly growing in production, pushing technology to continually reinvent itself with either new products or reductions in the cost of making existing products around different industries (R. C. Allen, 2006; de Steiguer, 1995; A. Khan, 2008). The service industry, for example, was motivated to increase sales and reduce labor costs, which led it to implement self-service systems in the 1930s. At that time, technology-based self-service came to the service industry with options such as self-price checkers, self-service checkouts in grocery stores, and automated teller machines (ATMs) (Anitsal et al., 2002).

The service sector has positively impacted the Gross Domestic Product (GDP) and promoted employment in the economically active population. The growth of this industry and its dominance in developing economies during the last decades has generated curiosity for research purposes (Stoshikj et al., 2016; Iglesias, 2018). Academics in North America and Europe are taking a new approach to services, viewing them as part of science for their ability to invigorate the economy. In the US alone, 75% of workers work in the service sector. According to the US Bureau of Labor Statistics (BLS), the service sector encompasses many industries. In 2020, the top four employment sectors in the US were education and health services, professional and business services, leisure and hospitality, and retail. The service sector also includes finance, communications, wholesale, insurance, transportation, real estate, logistics, postal operations, etc. (Hidaka, 2006; Holusha, 1989; Günay & Kurtulmuş, 2021). The breadth of the services sector makes it a dynamic, competitive, and attractive field for technological innovation.

Events such as the COVID-19 pandemic have also forced innovation within this sector. During this pandemic, the world economy experienced the worst crisis since the Great Depression of 1930. According to the International Monetary Fund (IMF), in 2020 alone, GDP fell by 3.5% worldwide, primarily due to significant losses in income from the service sector businesses such as bars and restaurants, hotels, educational institutions, and airlines. An impact similar to that of the Spanish flu at the end of the 20th century is estimated to have caused a GDP decline of 6% after its onset. (Açikgöz and Günay, 2021; Kurtulmuş, 2021).Technology led the situation during the 2020 pandemic, particularly in health and education. In the field of health care, most of the activities supported by technology and AI were the provisions of health services remotely, the prediction, detection, and monitoring of diseases in real-time around the world, and the analysis and visualization of disease spread trends (Vargo et al., 2021; Dananjayan & Raj, 2020). While in the educational system, schools had to provide emergency remote teaching to students from all over the world through electronic learning management systems such as Blackboard Learn, Moodle, ATutor, Sakai…, or cloud communication platforms such as Zoom, Microsoft Teams, WebEx, etc. (Jia et al., 2021; Gladilina et al., 2020; A. M. Khan et al., 2021).

While technology is leading, AI is taking a prominent role in customer service, increasing significantly due to isolation and restrictions imposed during the pandemic. Free virtual assistants such as Hyro are examples where through AI, technology helps healthcare companies and their patients to assist them using a database compiled by the World Health Organization (WHO) and other trusted sources of information to answer questions from customers, helping to regulate the increasing flow of online users (Abuselidze & Mamaladze, 2021). AI, combined with other technology, is revolutionizing companies worldwide in different sectors by providing competitive and innovative products and services while executing mechanical and analytical tasks. In the service sector, AI and technology can be used as self-automated algorithm processors that can perform complex tasks to support customers and employees. Examples are used to predict customer behavior and generate personalized recommendations based on past data, such as customer behavior or preferences (Paluch & Wirtz, 2020).

Automation and AI have also made customers "active participants" in service encounters and how they want to experience them through introducing technology-based self-service (TBSS) options and service robots. According to the American Banking Association, in 2013, 56% of customers preferred to use mobile bank apps or ATMs rather than traditional services. Anitsal, Moon, and Anitsal (2002) stated that within service encounters, three characters, namely customer, employee, and technology, interact with one another in different interactive service options, evidenced from the beginning of the service transformation. For service marketing professionals, it's essential to understand the interactions that occur from various perspectives. The customer has always been part of these interactions. For example, customer-employee interaction denotes a complete service, which is known as a traditional encounter that requires low cognitive and emotional complexity. With the injection of technology in recent years, technology has become a new participant in these interactions. It has been observed from customer-technology, which is called self-service technology, to technology-employee interaction, which is known as service robots to serve employees and customers in tasks that require developing highly cognitive and analytical skills (Anitsal et al., 2002; Scherer et al., 2015; Wang et al., 2013).

Traditional services served as a development niche for service robots since the activities carried out there require low cognitive and low emotional complexity, such as carrying objects and undertaking monotonous assembly jobs. Technology and AI development have bet for top-of-the-line robots within the service industry to improve the service experience and reduce operating costs, goals the marketing field has been fighting for years to increase customers' standard of living. Now, it is sought that service robots also serve in services that require developing highly cognitive, analytical, and physical tasks within service encounters, such as assisting in medical surgery through voice-activated robotic arms or humanoid robots in hotel lobbies that welcome guests, carry the luggage to the guest room and even entertain them (Fusté-Forné & Jamal, 2021; Wirtz et al., 2021).

The ability of AI technology to execute mechanical, repetitive tasks cheaply and with no room for human error will disrupt service jobs, making it likely that service workers will gradually be replaced by robots in the future. Frey and Osborne (2017) estimate that 47% of jobs in the US are vulnerable to automation, and Lu et al. (2020) calculate this will happen by 2055. Empirically, it is believed that this wave of automation and AI technology was caused as a compensatory response to labor shortages, an aging population, and competitive needs in the industry. The New York Times estimates that by 2030, only 59 percent of adults aged 16 and older will be in the US workforce, down three percentage points from 2015 (Schneider et al., 2018; Nelson, 2017). Authors such as Fauxet (2021) estimate that by 2025, robots will substantially impact the market, reaching 1.5 billion dollars. In the United States, a robot has already been developed to cook complex meals and serve customers by replacing an entire staff of employees. In California, a hamburger robot has been designed to fulfill up to 120 orders per hour. For its part, Café X, located in some airports, has robotic baristas that can produce up to three drinks in 40 seconds (Fauteux, 2021; Koster & Brunori, 2021; Tuomi et al., 2021).

Service robots can adapt to different environments, unlike other technologies in producing and delivering services, such as (TBSS) options, service kiosks, or pre-programmed tablets. According to Wirtz et al. (2018), a "service robot" is an autonomous system that has the capacity to adapt while interacting, communicating, and delivering services to customers. Jörling et al. 2019, for its part, add that this autonomous system can provide personalized assistance in performing physical and nonphysical tasks. Two definitions agree with the International Federation of Robotics, which describes a service robot as an autonomous robot that performs tasks without human intervention. Bowen and Morosan (2018) also add that autonomous machines could have a human, animal, or object functional morphology. For this research, service robots would be defined as adaptable, highly autonomous machines that develop physical and cognitive/analytic complex tasks during service encounters (Fusté-Forné & Jamal, 2021; Paluch and Wirtz, 2020).

Advances in AI have fueled the development of machine capabilities in response to its popularity. Autonomous machines are highly complex AI-powered systems that integrate different technology segments without human intervention (Liu & Gaudiot, 2022). These systems are widely used in various industries and customers' daily lives. For example, autonomous vehicles, smart manufacturing robots, and service robots (Chen et al., 2021; Ignatious et al., 2022; Zhang et al., 2020). These autonomous machines must also include cognitive/analytical and social/emotional skills to effectively and naturally collaborate or assist humans. Features such as action, perception, and reasoning of language, gestures, touch, and facial expressions must be built into robots to support human-robot interaction, especially in service encounters. For example, in the health care industry, a nursing robot capable of feeding patients must be able to follow the movements of the patient's head but must also understand the subtle clues that indicate when the patient is ready for the next bite through interpretation of voice, facial expressions, and patient gestures (Ahn, 2018; Lange, 2019). Cognitive/analytical skills are mental abilities that must function correctly, such as memory to retain information, processing speed, and logic to solve problems. Social/emotional skills mean the ability to analyze and regulate human emotions and display them. What authors like (X. Liu et al., 2015) call emotional Intelligence (X. Liu et al., 2015; Manivannan, 2019).

Service robots can adopt human capabilities to perform simple or complex tasks depending on the requirements of the service encounter. Service robots, such as holograms or mechanically designed robots, can be designed virtually or physically. Mechanically designed robots (physical robots) must develop their designs considering a particular environmental niche in which they are to perform. When establishing the design, the expected behavior the robot will adopt during physical tasks within the service industry should be determined, such as the social/emotional and cognitive/analytical skills necessary for customer satisfaction (Nassiraei & Ishii, 2007; Vujovic et al., 2017). Customer satisfaction is the primary goal of a service encounter. The consumer-machine interaction must be considered when deciding the most relevant mechanical design, as well as the morphological representation of the robot, such as human, animal, or object appearance.

Anthropomorphism in robots seems to be a determining factor in consumer-machine interaction, where imitating male or female characteristics in a robot increases consumer confidence and influences decision-making related to automation technology (Belanche et al., 2020; Singh & Sellappan, 2008). Robots that include human physical characteristics such as eyes, nose, hands, arms, legs, and mouth, and nonphysical human features such as gestures, voice, or personality appear to be physically, cognitively, and socially accepted by consumers. Singh and Sellappan (2008) identified robots that mimic humans through perception, processing, and action as humanoid robots. Humanoid robots can be deployed in sensitive environments to interact with fragile service encounters such as health and in intense environments such as military usage (Chuah et al., 2021; Lyons et al., n.d.; Singh & Sellappan, 2008). While human physical features have already been developed in robots, nonphysical human parts are starting to be incorporated for their importance to customer satisfaction in the service industry. For example, an engineering company based in the UK has developed a robot named AMECA that physically looks like a person and displays human expressions such as surprise, wonder, curiosity, and happiness (Engineered Arts, 2022).

As with technology in the industrial revolution, customers have seen the evolution and growth of intelligence in robotics and AI. Robots are destined to become a pervasive aspect of modern society because of their growing ability to support the performance of human tasks while improving customers' lives (Lyons and Nam, 2021). In 1959, the first industrial robot was developed and introduced in the US as a hydraulic machine programmed in joint coordinates. Industrial robots are intended for simple tasks such as device transport, assembly, welding, and painting due to the design and purpose that have been determined according to the industry in which they work. Service robots, meanwhile, are intended for complex tasks, so they must be flexible, autonomous, and easy to operate (Savin et al., 2022; Singh & Sellappan, 2008). We listed various types of robots, their definition, possible classification labels, and examples below. This table may help entrepreneurs to identify needs and gaps in design and development efforts.

TABLE 1 – TYPES OF ROBOTS AND EXAMPLES

NAME	DEFINITION	LABEL	EXAMPLES
Delta robots[1]	Its configuration includes arms with rotating or concurrent prismatic joints that can execute precise and minute movements.	Industrial robot	High-precision assembly operations robots. Packaging industry robots. Operating room assistant robot.
Polar coordinate robots[1]	Its configuration includes an arm with two rotating joints and a linear joint connected to a base with a rotating joint. The robot axes work together to form a polar coordinate, allowing the robot to work spherically.	Industrial robot	Surveillance robots. Environmental monitoring robot. Underwater and planetary exploration robot.
Articulated robots[1]	Its configuration contains a rotary joint, simulating the rotation of a human arm. It can move on flat terrain and narrow spaces.	Industrial robot	Welding robot. Assembly robot. Material handling robot.
Teleoperated robots[1,2]	Its configuration allows it to be teleoperated by a human operator who controls the robot's movements from a distance through devices such as personal digital assistant (PDA) systems or cell phones.	Industrial robot	Robots with multi-panel displays with control devices like joysticks, wheels, and pedals.
Hybrid[3,4]	Its configuration is based on automatic systems that use a combination of wheels (or tracks) and legs in different formations to perform locomotion.	Human server and cobot	Wheels are attached to the end of the legs. Combination of wheels and legs operated independently.
Pre-programmed robots[5,6]	They are autonomously preconfigured, so they cannot change their behavior while working and are not supervised by humans.	Human server and cobot	Roomba Robot Vacuum[7]
Animatronics[8,9]	They physically look like real people or animals. They are generally used in movies and other entertainment industry settings.	Humanoid robot	Disney show/movie performance robots.
Bipedal[10,11]	They are configured to mimic the gait of a human being. It can be scheduled to perform some tasks as needed.	Humanoid robot	The locomotion of a bipedal walking robot with six degrees of freedom.
Autonomous mobile robots[12]	Its configuration allows navigation in environments without needing physical or electromechanical guidance.	Robot	Hospital assistance robots. Agriculture assistance robots. Services robots.
Automated guided robots[13,14]	Its configuration is automated and guided by a contactless guidance system that moves and transports items in production, storage, and distribution centers.	Robot	Guided carts. Tow tractors. Mobile picking robots.
Android / Gynoids	It is configured as a humanoid robot. Its design will resemble a male human (Android) or a female human (Gynoid).	Humanoid robot	Sophia[20]: Female humanoid robot capable of displaying humanlike expressions and interacting with people.
Humanoids[16]	It was configured to mimic the general appearance of the human body, its movements, and human interaction.	Humanoid robot	Eva: Adult-sized humanoid with emulation of human facial expressions, head movements, and the ability to speak, using 25 artificial muscles.[15]

Cobots[17,18]	Its configuration allows one to physically interact with humans in a shared workspace.	Humanoid robot	Object position robot. Bar code identification machine.
Augmenting robots[19]	Its configuration generally allows for enhancing a person's capabilities or replacing abilities that a person has lost.	Humanoid robot	Robotic prosthesis in medicine.
Social robots[22,23]	Its configuration is the same as a humanoid robot but programmed to "socially" interact with humans and provide physical and emotional support.	Humanoid robot	Asimo[22]: Can understand and respond to simple voice commands and recognize the faces of a select group of individuals.
Biohybrid robots[24]	They are composed of biological and synthetic components that have the potential to be fully autonomous, intelligent, and self-assembled. Capable of learning from previous experience and repairing their damage or injury.	Humanoid robot	Biologically inspired manta ray-shaped robot.
Sources: [1] Process Solutions (2018), [2] Valero-Gomez and De la Puente (2011), [3] IGI Global (2022), [4] De Luca et al. (2021), [5] Gottlieb and Anderson (2011), [6] Das (2022), [7] Forlizzi and DiSalvo (2006), [8] Stan Winston School of Character Arts (2015), [9] Baradwaj (2020), [10] Perkins (2021), [11] Lim and Yeap (2012), [12] Jacoff et al. (2002), [13] Bore et al. (2019), [14] Lin et al. (2021), [15] Faraj et al. (2021), [16] Song and Kim (2022), [17] Biton et al. (2022) and Beuss et al. (2021), [18] & [19] Gottlieb and Anderson (2011), [20] Hanson Robotics, (2022), [21] Sakhineti and Jayabalan (2020), [22] Okita et al. (2009), [23] Piçarra and Giger (2018), [24] Mestre et al. (2021)			

Table 1 highlights the different types of robots based on their design and programming. Industries have been a niche for robot technology and development. In the manufacturing industry, for example, robots with a mechanical structure capable of performing complex tasks with high precision, such as delta and polar coordinates, and articulated robots are the most used and demanded. The retail industry, for instance, has adopted robots to perform repetitive tasks performed by teleoperated, hybrid, and pre-programmed robots. At the same time, the service industry has adopted robots such as autonomous mobile robots, automated guided robots, cobots, social robots, and humanoids to be the most flexible regarding the environment or task adaptability. The variety of robot combinations has become a very popular and demanded market in recent years, which is why Reshetnikova and Pugacheva (2022) expect the robot market to exceed 61.4 billion dollars by 2025, while Chuah et al. (2021) forecast just $102.5 billion for service robots by 2025. The use of AI is growing, and despite its relevance and current popularity in customers' lives, finding other robot developments was not easy. Table 1 summarizes the most popular robots, but the spectrum is even broader, so more research is needed for better insight.

The current study proposes a task-oriented physical robot deployment model by skills (Figure 1), including social/emotional, cognitive/analytical, and physical skills. As Moon and Anitsal (2002) did with the TBSS, this article presents a helpful classification of service robots to understand the possible combinations, interactions, and full potential of skills based on the complexity of the tasks. According to their complexity, the tasks are performed based on three different types of AI: Mechanical AI, Thinking AI, and Feeling AI (Huang & Rust, 2021). The types of AI provide a better understanding of the possible tasks performed by service robots covered in this article. Mechanical AI focuses on tasks with standardized, consistent, and reliable results. Some examples would include high-precision object positioning, packaging, and assembling. Thinking AI focuses on tasks that provide customer personalization, for example, voice and face recognition, weather-based outfit suggestions, and memorizing customer preferences (Huang & Rust, 2021; Klein et al., 2020). Feeling AI focuses on tasks based on emotional intelligence, such as recognizing and responding to customer emotions, displaying own emotions, and empathy (Huang & Rust, 2021; Sayed & Gerwel Proches, 2021).

Service robots that share a work domain with customers should be able to handle multiple tasks simultaneously with real-time responses. Service robots cannot fully satisfy all customer demands with autonomous decision-making. Service robots currently lack emotional intelligence and inference mechanisms to predict customer requirements. So far, task-oriented service robots have been developed based on human skills (Kim & Yoon, 2014; Letheren et al., 2021). The classification of robots in the service industry can be represented by interactions between customers, employees, and robots with three types of skills. (1) social/emotional skills, such as emotional intelligence or expression of emotions; (2) cognitive/analytical skills, such as communication or long-term memory; and (3) physical skills, such as lifting weights or moving steadily. The skills of service robots are based on three types of AI (Mechanical, Thinking, and Feeling) and are tied to the simplicity or complexity of the assigned task (Wirtz et al., 2021).

Social/emotional skills for simple and complex tasks: ***(1a and 1b)***

The use of social/emotional skills to perform simple tasks is shown as (1a) in Figure 1 by human servers and collaborative robots (cobots) based on Feeling AI. Cobots are designed to work with humans simultaneously in the same workplace. For example, in the health industry, cobots are integrated into simple surgical processes, such as routine oral and maxillofacial interventions (Chromjakova et al., 2021; Huang & Rust, 2021). The cobot is programmed to predict the doctor's activities based on different parameters using systems that have copied the movements of the human assistant to transfer them to the robot. In this scenario, the human-robot social/emotional interaction is as simple as a movement assistant (Beuss et al., 2021). When complex tasks are combined with social/emotional skills, it is determined as (1b) and performed by a partial employee. The customer acts as a partial employee by performing some tasks by themselves, replacing specific tasks performed by service providers, improving customer satisfaction (Hsieh et al., 2004). In the retail industry, self-checkout systems have been implemented to provide a good experience for customers, allowing them to scan items and pay for them without interacting with human employees and providing more privacy during service delivery. Hence, the quality of service falls mainly on the customer (Aquilina & Saliba, 2019).

Cognitive/analytical skills for simple and complex tasks: ***(2a and 2b)***

The use of cognitive/analytical skills to perform simple and complex tasks is shown in (2a) and (2b), respectively, based on Thinking AI and performed by robots. Robots with cognitive/analytical capabilities based on thinking artificial intelligence are mainly programmed to perform personalized tasks for the client according to their preferences. In simple tasks, for example, the robots are programmed to recognize the commands of a customer through their voice (Gundogdu et al., 2018). Robot programming uses a metaprogramming approach that allows customers to customize simple commands such as move, select, and drop with their voices. While in complex tasks, the robots are programmed, for example, with an algorithm for recognizing orders and customer habits, which can open various types of doors in a house in the same way and at certain times based on the daily routine of the client, without the need for the client to command it (Li & Meng, 2015; S. Park, 2020).

Physical skills for simple and complex tasks*: (2a and 2b)*

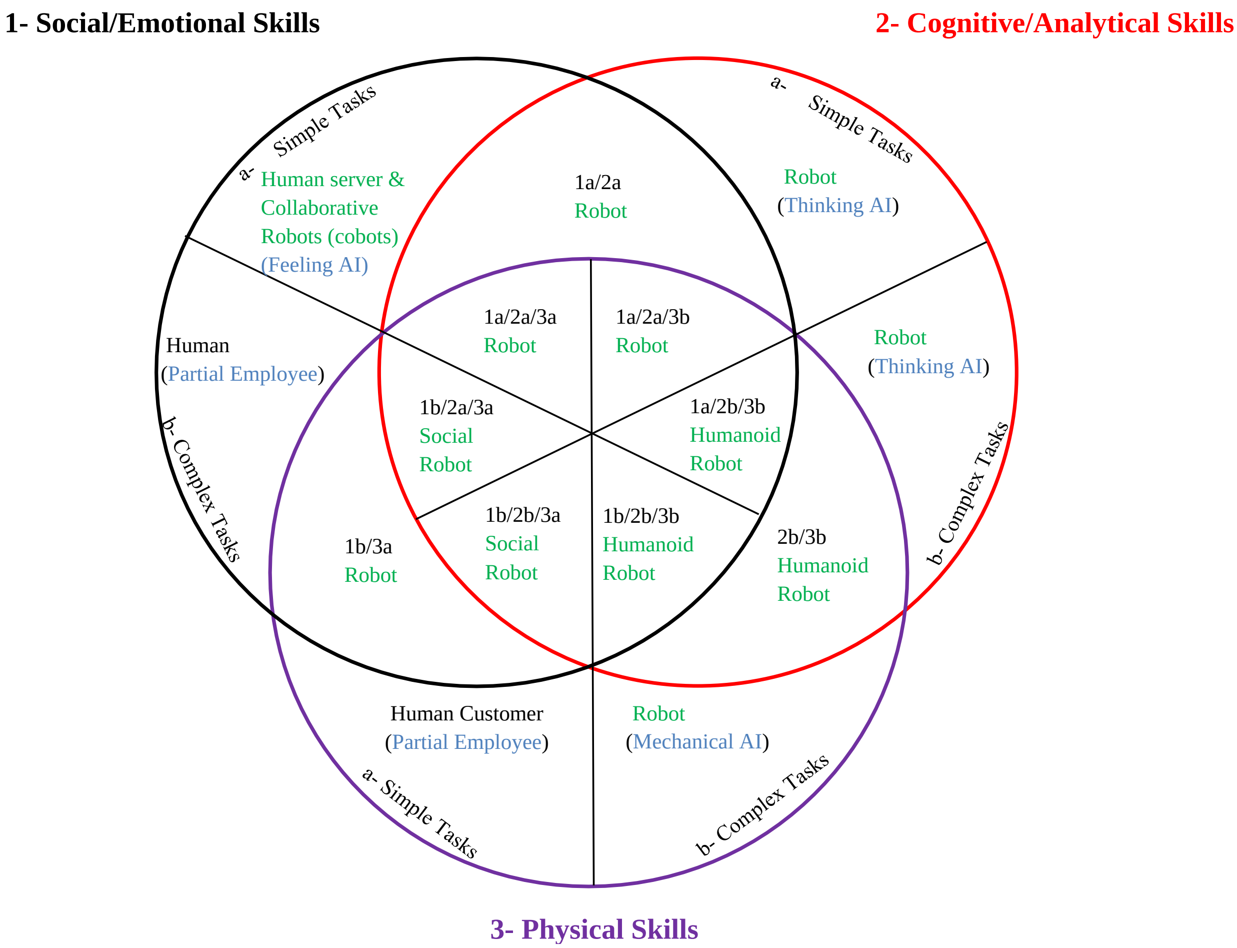
When physical skills and simple tasks are combined, as seen in (3a), they are performed by a Human Customer (Partial Employee). A simple job with physical skills could be seen in the self-checkout example. Customers are expected to scan each product on the scanner, pack them in bags, and pay manually (Aquilina & Saliba, 2019; Considine & Cormican, 2016). The use of physical skills to perform complex tasks is denoted as (3b) and performed by mechanical AI-based robots focused on precision and standardized results. For example, the Roomba robotic vacuum cleaner is capable of moving autonomously around any surface, such as wood, ceramic, or carpet. Its programming allows it to brush and vacuum even the most minor dirt and dust in seconds, while a human would take hours. (Forlizzi and DiSalvo, 2006).

Intersections of social/emotional and cognitive/analytical tasks

At intersections, we see lots of opportunities for robot development. Simple tasks performed with social/emotional and cognitive/analytical skills are represented as (1a/2a) and are performed by a robot. The robot can assist a human employee in simple tasks based on feeling AI and thinking AI. For example, in a laboratory where SARS-CoV-2 tests are carried out, the assistants were helped by automation, where a robot assumed the role of laboratory technician. The robot assists in simple activities such as sample preparation, pipetting, and liquid handling under the supervision of the human employee as a simple human-machine interaction (Zanchettin & Facciotti, 2022). Robots can also develop physical skills to perform simple and complex tasks. The performance of simple duties in this type of robot is denoted as (1a/2a/3a). This means the robot can move autonomously in an austere environment like a laboratory. Performing complex tasks with physical skills in the same scenario is denoted as (1a/2a/3b) and means, for example, the robot can take and transport the samples for later processing stably.

The utilization of social/emotional skills to perform complex tasks and physical skills to perform simple tasks is denoted as (1b/3a) and performed by a robot. The robot can interact with customers, but its physical skills are simple. For example, in self-checkout systems, the machine is capable of interacting with the customer by giving visual and voice instructions through the screen but physically is capable of weighing the fruits or vegetables once the customer places them on the scale (Aquilina & Saliba, 2019; Considine & Cormican, 2016). (1b/3a) based robots can also develop cognitive/analytical skills to perform simple and complex tasks and become social

FIGURE 1 - A MODEL OF TASK-ORIENTED PHYSICAL ROBOT DEPLOYMENT BY SKILLS



Sources: Extended from Wirtz et al. (2018), Wirtz, Kunz, and Paluch (2021); Colgate et al. (1996); Huang and Rust (2020); Belanche et al. (2020); Chromjakova et al. (2021); Beuss et al. (2021); Stipancic et al. (2021); (Hsieh et al. (2004) robots. Social robots are explicitly designed to be "social" and improve human-robot interactions (Coeckelbergh, 2021; Zonca et al., 2021).

The involvement of cognitive/analytical skills to perform simple tasks is denoted as (1b/2a/3a). This means that social robots, for example, process the product's price based on its weight while giving instructions to the customer (Coeckelbergh, 2021). Performing complex tasks with cognitive/analytical skills is denoted as (1b/2b/3a). Here, the social robot can reach a higher level of AI, and for example, the PLEA robot was designed as a teaching social robot. PLEA is an autonomous humanoid head capable of teaching and interacting with students in a classroom just as a teacher. PLEA can also assess and predict students' emotional states and alter the teaching process by changing the tone of voice or asking questions about the student's state of mind and self-understanding. (de Montfort University, 2021; Stipancic et al., 2021).

The performance of complex tasks using cognitive/analytical and physical skills is denoted as (2b/3b) and is performed by a humanoid robot. The humanoid robot is designed to mimic the general appearance of the human body and its movements. Physically, humanoid robots look like humans and can mimic simple physical tasks, such as head movements and facial expressions, and their cognitive/analytical skills are as complex as a robot (Faraj et al., 2021; Pepito et al., 2020). The entertainment industry has pioneered the use of humanoid robots, but they have been cataloged as animatronics because they are designed to entertain customers rather than interact with them. When social/emotional skills get involved, the scope of tasks performed by humanoid robots changes (Baradwaj Yellenki, 2020; Stan Winston School of Character Arts, 2015).

A humanoid robot programmed to perform complex tasks with cognitive/analytical and physical abilities but simple tasks with social/emotional skills is denoted as (1a/2b/3b). Examples of this combination of skills and tasks can be seen in the entertainment industry, such as casinos. Some casino owners in Las Vegas have started using a robot prototype to replace the dealers. The humanoid robot is a prototype called Min, which physically looks and mimics a dealer, can perform card dealing functions, and even detect cheating during gameplay, but still without social interaction with customers. (McCoy, 2019). In the past few years, authors such as (Chiang et al., 2022) state that humanoid robots have begun to be designed under experimental conditions to perform complex tasks with social/emotional skills, such as recognizing facial emotions, movements, or sounds of customers. For example, a robot named Ameca has been popularly listed as the world's most advanced and realistic humanoid robot. The robot has been designed by Engineering Arts, a company dedicated to manufacturing humanoid entertainment robots for companies, theme parks, and science centers (Alfonso, 2022; Gomez, 2021). Ameca is currently a prototype with an artificial intelligence and machine learning platform that stores data in the cloud while interacting effectively with customers. Ameca has a combination of artificial limbs and ligaments that simulate human movements. The robot can smile, blink, show surprise, and scratch its nose. Ameca can also detect people, track their faces, detect objects, and even have fun looking at a customer (Osmond, 2022; Yi Joey, 2022). This humanlike robot aims to bridge the gap between customers and digital life. Its current software makes the humanoid robot ideal for customer service; however, its developers seek to improve its software to be constantly reprogrammed and updated by adding new functions (Alfonso, 2022; Gomez, 2021).

MANAGERIAL IMPLICATIONS AND FUTURE RESEARCH AVENUES

Robots have moved from the traditional manufacturing industry into human environments such as work and personal life (Savin et al., 2022). Combining technology and artificial intelligence has allowed robots to respond to different environments and adapt to various industries, such as the service industry. The changing nature of the industry and factors such as COVID-19 have driven services such as hotels, restaurants, and health centers to rely on technology to meet their needs. The imposed distancing and labor scarcity as pandemic consequences have pushed robots to take jobs with repetitive tasks. Authors such as Paluch and

Wirtz (2020) point out that AI and robots have also begun to take a dominant role in customer service in response to said isolation and restrictions. Robots have started to develop more abilities that allow them to perform mechanical and analytical tasks beyond the traditional ones used by industrial robots.

The service industry has been cataloged as an industry of high quality in customer satisfaction (Choi et al., 2020; Lu et al., 2020). Today, we see robots capable of performing complex tasks to serve customers in restaurants and hotels or as a human-machine team in technology-based self-service trying to bring an excellent experience to customers (Anitsal et al., 2002; Wirtz et al., 2021). However, El-Said and Al-Hajri (2022) argue that many researchers in the "customer service" field conclude that there is a general preference for human service in the service industry. AI has not yet reached the point of fully satisfying the service industry. Robots cannot match the quality of service characterized by personalized service, the human touch, and authentic customer-employee interactions. The key to successful service delivery is to ensure pleasant interactions for those involved. A pleasant interaction with a customer includes empathy and emotional intelligence from the service provider (Ho et al., 2020; Prentice et al., 2022; Sayed & Gerwel Proches, 2021).

In order to reach customer satisfaction, the goal of service delivery, robots should include natural human basic skills. According to Turja et al. (2022), in addition to physiological requirements, customers have basic psychological needs, such as feelings of competence, autonomy, and social relatedness. Huang and Rust (2021) have identified three types of AI, Mechanical AI, Thinking AI, and Feeling AI, to which service robots are adaptable and on which they are based to perform simple or complex tasks according to customers' requirements. Service robots have been dispersed into different categories to meet customers' needs, based on the combination of human skills and artificial intelligence to carry out various tasks within the service industry.

Considering the necessity of social/emotional, cognitive/analytical, and physical abilities, in combination with AI and the complexity of their tasks, a classification of robots according to a specific environment and purpose is needed (Huang and Rust, 2021). For example, conversational agents or chatbots use a combination of social/emotional skills and cognitive/analytical skills to perform simple tasks, such as conversing verbatim or with voice. Also, recognize customer requests by predicting customer behavior through feeling and thinking and thus propose solutions. When the physical capability, the ability for autonomous mobility, is added to the chatbot, we are no longer talking about a virtual assistant but a physical assistant. This physical assistant can be used, for example, in the care of the elderly, not only providing them with company through conversations but also helping them with physical tasks such as making their bed (Biton et al., 2022). The robot with the three abilities moves to another environment where its social/emotional and cognitive/analytical skills are needed. Still, its physical ability takes it to a more advanced level, reaching another audience and performing different tasks.

Japan, South Korea, the United States, and some European countries have been pioneers in implementing service robots and investing in their development (Ward and Ashcraft, 2010). There is a distinction in the adoption of robots in advanced and developing countries, as discussed by De Vries et al. (2020). Investment in robotization is closely linked to the economic capacity of the country's industries where it is implemented. Therefore, it is inferred that since developing countries have an emerging economy with a lot of inexpensive labor available, investment in technological structure is not as significant as in advanced countries (Awnan and Ali Khan, 2015; Vo et al., 2017). To facilitate the implementation of robots in the service industry in countries with emerging economies, this study suggests developing and implementing policies that allow the identification of the economic and structural benefits after adopting service robots in companies. Companies will adopt service robots as long as they show technical and economic feasibility. Once implemented, robots improve the provision of services and, therefore, generate benefits above costs (Berg et al., 2016; Miller, 2017). Investing companies are also invited to assess the potential of markets in emerging economy countries for possible technology investments, considering the potential of these economies mentioned by (Awnan and Ali Khan, 2015). Regarding expectations, such as steady economic growth in the future due to a younger active population, the development of consumer markets, the expansion of the middle class, and the increase in exports may influence the adoption of service robots in emerging economies as well as the post-implementation economic benefits.

Once robotization reaches multiple countries with different economic structures, a wave of robots could spread into the markets and customers' personal lives, providing them many options, just as the internet did (Castells, 2013; Hackl, 2020). The current study shows how different skill combinations rank robots. Until now, the most advanced service robots are humanoid robots. In addition to having the three social/emotional, cognitive/analytical, and physical abilities, they can perform complex tasks while mimicking humans. Humanoid robots look not only physically similar to human beings but also display similar psychological states by recognizing customers' facial emotions, movements, or sounds under experimental conditions (Belanche et al., 2020). Söderlun (2022) points out that even several existing robots seem to recognize themselves in a mirror, an ability that requires a relatively advanced form of intellect. Researchers such as Saegusa et al. (2014) and Stoytchev (2011), mentioned by Söderlund (2022) in his paper, have noted that once robots are truly capable of recognizing themselves, this would improve their abilities to interact with customers, use new tools, self-repair or even become a customer.

LIMITATIONS AND CONCLUSION

Service robots are a fast-developing area in the services industry, especially gaining momentum after the COVID-19 experience, so much so that market development is way ahead of academic business research. In this conceptual paper, we intend to explore, summarize, and organize the recent developments in automation and artificial intelligence pertaining to the service industry. We recognized a gap between academic discovery and marketplace applications regarding service robots.

Our research enabled us to design a framework to direct research to analyze customer-employee-technology interactions based on the skill sets of related parties. As far as we know, this framework may be one of the first attempts to organize robot development activities around the necessary skills in service marketing. The framework is definitely not exhaustive, as the research is moving very fast. We focused on the social/emotional, cognitive/analytical, and physical skills as the most relevant in customer, employee, and technology relationships in multitude of service situations. There may be other variables that are worth considering. Development of such variables, data collection, and analysis methods are beyond the scope of this paper.

As indicated in the future research avenues section, the design and development of service robots and their impact on customer-employee-technology interactions are wide open for new research. Even though we have not approached this topic from any existing research philosophy perspectives in mind, the framework may help researchers from positivist or relativist paradigms design their investigations better. Indeed, the opportunities for further research make this topic very exciting.

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TRANSFORMING HEALTHCARE: THE ROLE OF MOBILE TECHNOLOGY IN DEVELOPING NATIONS

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ABSTRACT

Mobile technology has the power to make an impact, on healthcare in developing nations. It has the ability to enhance healthcare accessibility and empower individuals to take charge of their well-being and enable the collection of real time health information. Nevertheless, there are obstacles that must be overcome including infrastructure, concerns regarding data privacy and disparities in access. The main goal of this research article is to explore how mobile technology affects healthcare systems in developing nations identifying patterns, difficulties and potential advantages. We conducted a comprehensive review on previous studies and systems that focus on the utilization of technology, in healthcare, within developing nations. This article examines how mobile technology influences healthcare systems in developing nations. It highlights patterns, obstacles and prospects while providing insights, into how these systems can utilize mobile technology to enhance the accessibility, quality and efficiency of healthcare services.

Keywords: *mobile technology, mobile health, mHealth, healthcare, developing countries, impact.*

INTRODUCTION

The digital revolution is currently taking place worldwide. One significant factor driving this change is the use of mobile technology. Smartphones and tablets have seamlessly integrated into our daily lives with 5.28 billion people using phones globally in 2021 (Statista, 2021b). These devices have revolutionized aspects of our routines but their impact on healthcare stands out as particularly remarkable. Mobile technology has proven to be a tool in improving access to healthcare services enhancing delivery methods and achieving outcomes especially in developing nations.

Healthcare, in developing nations is commonly marked by limitations in resources, insufficient infrastructure and unequal access to services. As a result, people in these areas face difficulties in obtaining high quality healthcare, which contributes to the prevalence of diseases, increased mortality rates and a decline in well-being (World Health Organization, 2018). Fortunately, mobile technology presents a solution that could help tackle these healthcare issues.

A "developing nation" is typically defined as a country with a lower level of industrialization, lower standard of living, and lower Human Development Index (HDI) compared to more developed countries. These nations often face challenges such as higher poverty rates, limited access to healthcare and education, and inadequate infrastructure.

Developing nations are countries with a lower standard of living, underdeveloped industrial base, and low Human Development Index (HDI) relative to other countries. They often have lower per capita income levels, less access to healthcare and education, and generally lower life expectancy (UNDP, 2020; World Bank, 2021).

Through this investigation we delve into how mobile technology can enhance healthcare in developing countries. Our goal is to showcase the impact that mobile technology has on delivering healthcare services. By analyzing a collection of research case studies and reports we explore the prominent patterns, obstacles and prospects associated with mobile technology in the healthcare sector of developing nations.

It's undeniable that mobile technology has spread rapidly across the world. In 2021 there were 5.28 billion individuals using phones, which accounts for roughly 67.5% of the global population (Statista, 2021b). The availability and affordability of devices, in economically disadvantaged areas with limited resources have played a significant role in this widespread adoption. Developing countries in particular have witnessed growth in mobile phone usage over the twenty years with a substantial increase in mobile phone subscriptions.

The widespread use of technology offers a chance to address healthcare disparities in developing nations. By utilizing the capabilities of devices and networks we can extend healthcare services to underserved populations improving accessibility and ultimately leading to better health outcomes.

One significant result of the merging of technology and healthcare is the concept known as Mobile Health or mHealth. MHealth involves using smartphones, tablets, and other mobile devices to provide healthcare services, facilitate medical research and promote health related information and awareness (World Health Organization, 2011). The applications of mHealth are wide including the dissemination of health information, telemedicine services, remote patient monitoring and portable diagnostic tools.

The realm of mHealth has grown rapidly with an increasing number of applications and platforms, for both healthcare providers and consumers. These applications empower individuals to take charge of their health by granting access to information enabling remote consultations with healthcare professionals and facilitating the tracking of important health metrics. Notable examples include fitness apps that help users stay active, medication reminder apps that ensure adherence to treatment plans, as well as platforms that provide mental health support.

In developing countries particularly mHealth has emerged as a game changer by addressing the limitations in healthcare systems. For example, the use of health (mHealth) applications allows community health workers to reach villages monitor patients and gather important health data—all through their smartphones. This capability to expand healthcare services to populations has the potential to greatly impact healthcare outcomes in resource limited settings.

Mobile technology holds promise in reshaping healthcare delivery in developing countries across essential aspects, including improved accessibility, remote monitoring, dissemination of health information, data collection and surveillance and more. However, while the potential benefits are substantial there are also challenges and barriers that must be addressed. These include infrastructure development, bridging the divide, ensuring data security and privacy measures, navigating regulatory changes and so on.

Ultimately mobile technology has emerged as a force in delivering healthcare in developing countries. The adoption of mHealth solutions can enhance accessibility to quality care, iImprove the efficiency of healthcare services—ultimately leading to health outcomes for millions of individuals. Although challenges exist along this path, proactive measures such as infrastructure development initiatives promoting inclusion efforts implementing robust data governance can pave the way for a brighter and healthier future, in developing nations.

This research delves further into these factors utilizing a range of studies to offer a comprehension of how mobile technology contributes to the transformation of healthcare in developing nations.

LITERATURE REVIEW

Mobile technology has revolutionized healthcare in developing countries where access, to quality healthcare is often restricted by resources and infrastructure. This review paper provides an overview of the subjects, trends, obstacles and possibilities associated with leveraging technology to enhance healthcare services in those nations.

A key focus in the existing literature on technology in healthcare revolves around the adoption of mHealth applications and services. MHealth encompasses a range of tools and platforms aimed at improving access to healthcare, delivery of services and overall outcomes. For example, telemedicine apps allow healthcare providers to connect with underserved populations by offering consultations (Free et al., 2013). Mobile apps and text messaging services are utilized for distributing health information and promoting health literacy (Chib et al., 2013). Wearable devices and mobile apps enable monitoring of patients those with chronic illnesses (Labrique et al., 2013). Real time data collection facilitated by technology plays a role in disease surveillance and epidemiological research (Blaya et al., 2010). Moreover, initiatives utilizing technology have successfully improved child health through methods, like SMS based appointment reminders and educational programs (Atnafu et al., 2018).

Mobile health (mHealth) has the potential to educate individuals on diseases and their risk factors promote behaviors and offer reminders for vaccinations and preventive care. It can also aid in monitoring patients health status reminding them to take medications and providing support for self-management. Furthermore, mHealth can play a role in tracking the spread of diseases identifying outbreaks and coordinating response efforts.

One significant advantage of technology is its ability to extend healthcare services, to remote and underserved populations. Various studies have highlighted that mHealth interventions have effectively improved access to healthcare in areas where medical facilities are scarce (Free et al., 2013). By bridging barriers, mobile technology enables healthcare professionals to deliver care in inaccessible regions (Labrique et al., 2013).

However, it is important to acknowledge that there are challenges and barriers associated with implementing technology in healthcare within developing countries. Limited network coverage and unreliable electricity supply pose obstacles for mHealth solutions in those areas

(Tomlinson et al., 2013). Additionally, there is a divide where marginalized populations face restricted access to smartphones and mobile data exacerbating inequalities (Meurs et al., 2019).

Concerns regarding the security and privacy of data arise when it comes to mHealth as it involves the collection and transmission of health information (Aranda-Jan et al., 2014). The absence of frameworks for mHealth apps and services creates legal and ethical uncertainties (Fernandez-Luque & Bau 2015).

Various research studies have explored the influence of technology, on healthcare results. For instance, mHealth interventions have demonstrated promise in enhancing vaccination rates (Zurovac et al., 2013), decreasing child mortality (Atnafu et al., 2018), and effectively managing diseases (Labrique et al., 2013). These findings emphasize the improvement, in healthcare outcomes that mobile technology can bring to developing countries.

The literature suggests opportunities and future directions for using technology in healthcare within developing countries. Governments and organizations are encouraged to invest in improving infrastructure, such as expanding network coverage and ensuring electricity supply (Mars et al., 2014). Initiatives that bridge the divide through smartphones, digital literacy programs and subsidies for mobile data access can promote fair access to mHealth solutions (Meurs et al., 2019). It is crucial to develop data governance frameworks and ethical guidelines to ensure use of patient data, in mHealth applications (Mars et al., 2014). Governments, healthcare providers, technology companies, and researchers must come together to collaborate and find solutions, for the healthcare challenges faced by developing countries (Bashshur et al., 2015).

In a nutshell, based on the literature it is indicated that mobile technology has the potential to bring about a transformation, in healthcare delivery within developing countries. Its utilization in mHealth applications and services can lead to improvements in accessibility, health outcomes and the resolution of healthcare disparities. However it is essential to overcome challenges such as infrastructure limitations, bridging the divide and addressing concerns regarding data privacy to fully capitalize on the capabilities of technology, in these regions.

Gap the Current Study Aims to Address:

The literature review reveals that most existing studies on mHealth applications focus on developed countries, leaving a substantial gap in the context of developing countries. The review identifies several key areas where research is lacking:

Effectiveness and Impact: There is limited empirical evidence on the effectiveness and impact of mHealth applications in developing countries. Existing studies often lack rigorous methodologies and comprehensive evaluations.

Challenges and Barriers: The literature indicates that there are numerous challenges and barriers to the successful implementation of mHealth applications in developing countries, including technological, infrastructural, financial, and cultural factors. However, detailed analyses and solutions to these challenges are sparse.

User Acceptance and Adoption: Understanding the factors influencing user acceptance and adoption of mHealth applications is crucial for their success. Yet, there is insufficient research on these factors within the context of developing countries.

Sustainability and Scalability: Studies on the sustainability and scalability of mHealth interventions are limited, particularly regarding how these applications can be integrated into existing healthcare systems in developing countries.

The current study aims to address these gaps by conducting a comprehensive analysis of mHealth applications in developing countries. It aims to fill the significant research gaps identified in the literature by providing comprehensive and empirical insights into the effectiveness, challenges, user acceptance, and sustainability of mHealth applications in developing countries. This will ultimately contribute to more informed and effective deployment of mHealth technologies, improving healthcare delivery and outcomes in these regions.

RESEARCH METHODOLOGY

To fully comprehend the potential of mobile technology in healthcare, a systematic literature review (SLR) approach was adopted to collect freely available online content and articles published. Brocke et al. (2015) recommends that researchers conducting SLRs should make clear decisions on selecting databases and journals, defining search terms, selecting criteria for including and excluding papers, and developing strategies for citation analysis. In this particular study, special emphasis was placed on collecting sample articles from various database sources, including the open-access Google Scholar database, SCOPUS, IEEE, Science Direct, and ACM due to the innovative nature of mobile technology and the longer time frames required for reviews.

The criteria for inclusion of content in the review required that the article be published in complete form, whether in a journal, conference proceedings, technical report, white paper, or blog, and be written in English. Various search terms such as “mobile health in developing nations/countries”, mobile technology in healthcare”, “mHealth in developing nations/countries”, etc. were used to satisfy PRISMA conditions (Moher et al., 2009). The PRISMA framework specifies an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses and has been widely utilized in academic studies (Kruse et al., 2016).

Using PRISMA for the analysis allowed for the employment of guidelines to review clearly formulated questions and use systematic and explicit methods to locate, select, and critically evaluate relevant publications to address the research questions identified earlier. In addition to academic publications, technical reports and prominent blogs were reviewed to ensure the rapidly changing nature of mobile technology is reflected in the study.

Fig. 1 displays the screening and selection process of the artifacts finalized for the study.

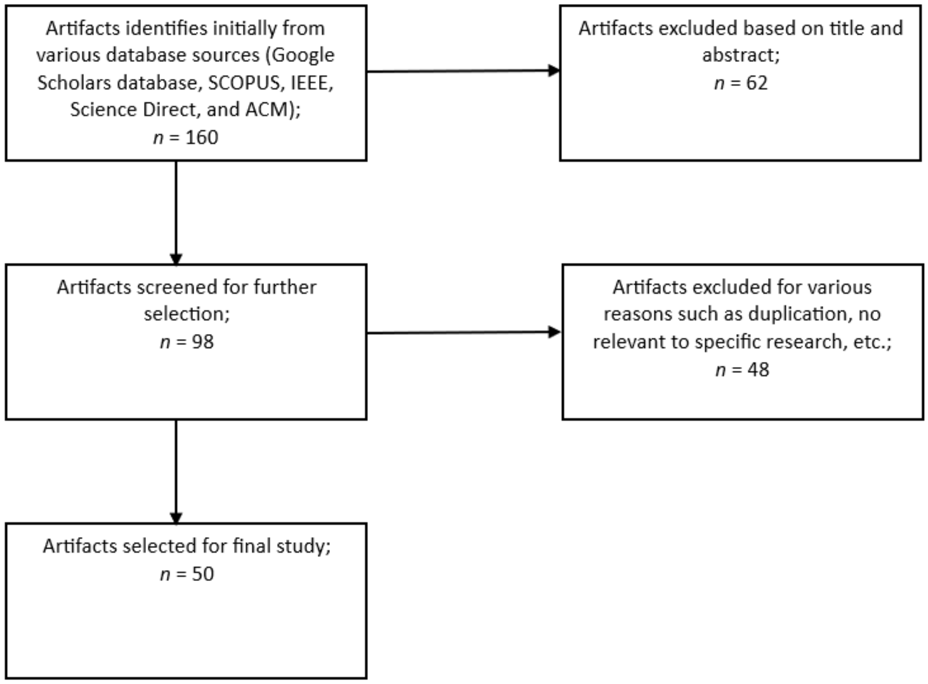

Fig. 1. Screening and selection process of the artifacts finalized for the study.

MAJOR APPLICATIONS AND SERVICES

Some of the major applications and services of mHealth in developing countries are described below.

Mobile-Based Health Information Services

Mobile phones are extensively used in developing countries to share health information through text messages or phone calls. These messages cover topics, like child health, nutrition, disease prevention and family planning. The main goal of health information services is to improve peoples knowledge, about health and promote practices (Chib et al., 2013).

Telemedicine and Remote Consultations

Telemedicine applications allow healthcare professionals to remotely consult with patients in areas that lack medical services. Patients have the ability to connect with doctors or specialists via video calls or text messaging, facilitating diagnosis, treatment and access to guidance (Free et al., 2013).

Mobile-Based Data Collection and Disease Surveillance

Mobile technology is extensively utilized in healthcare research, epidemiology and disease surveillance, for data collection purposes. Health professionals and researchers leverage devices to gather real time information regarding disease outbreaks, vaccination rates and health indicators. This allows for prompt responses to public health issues (Blaya et al., 2010).

Medication Adherence and Health Monitoring

Mobile apps and text message reminders are used to improve the adherence of patients, with illnesses such as HIV/AIDS, diabetes and hypertension. These tools assist patients in keeping track of their medication schedules and offering information to healthcare providers (Labrique et al., 2013).

Maternal and Child Health Services

Health (mHealth) apps play a role, in enhancing the well-being of both mothers and children. They achieve this by sending text messages containing advice, on pregnancy, infant care, appointment reminders and vaccination schedules. The primary goal of these services is to minimize mortality rates, safe childbirth practices and guarantee that children receive the necessary healthcare services they require (Atnafu et al., 2013).

Emergency Response and Disaster Management

Mobile technology plays a vital role, in emergency response and disaster management. It enables authorities and first responders to effectively coordinate relief efforts, share information, and provide assistance to communities affected by disasters and health emergencies (Mars et al., 2013).

Mobile-Based Point-of-Care Diagnostics

The use of technology, for point of care diagnostics is on the rise. Healthcare professionals can now utilize devices and smartphone applications to perform diagnostic tests in resource limited settings, including infectious diseases, like HIV or malaria. This advancement allows for diagnosis and prompt initiation of treatment (Drain et al., 2014).

Mobile-Based Nutrition and Dietary Support

Mobile applications and messaging platforms provide resources, for individuals and families offering information assistance with meal planning and advice, on maintaining a diet. The objective of these tools is to address malnutrition concerns and promote the adoption of eating habits (Haberer et al., 2016).

Mobile-Based Health Financing and Insurance

Mobile technology plays a role, in making health financing and insurance schemes more accessible. It enables individuals to conveniently pay for healthcare services, premiums and insurance coverage using wallets or payment platforms (Chen & Chen., 2018).

Mobile-Based Mental Health Support

Mobile health applications offer assistance, for well-being encompassing stress reduction techniques, therapy sessions and the ability to track mood changes. These applications are designed to tackle the increasing health issues faced by developing nations (Kaonga et al., 2019).

Mobile-Based Maternal and Neonatal Health Monitoring

Healthcare providers can utilize applications to monitor the health of both mothers and newborns effectively identifying any potential concerns that may arise throughout the pregnancy and childbirth process. This innovative technology plays a role, in minimizing the risk of mortality as highlighted by Lund et al. (2012).

Mobile-Based Pharmacy and Drug Information Services

Mobile apps and text messaging services offer ways for patients to access information, about medications, receive reminders to take their medication and locate pharmacies (Hall et al., 2016).

These mobile health applications and services have an impact, on enhancing healthcare availability, delivery and results in developing nations by utilizing the presence and easy accessibility of mobile phones.

MAJOR EXAMPLES OF SUCCESSFUL MHEALTH INTERVENTIONS IN DEVELOPING COUNTRIES

Some major examples mHealth interventions in developing countries are described below.

Mobile Telemedicine in Rwanda

The "Mobile Telemedicine and eHealth" program, in Rwanda has been remarkably successful, in leveraging technology to facilitate healthcare consultations from a distance. This initiative allows healthcare professionals working in areas to connect with medical experts located in urban centers guaranteeing that patients receive prompt and expert attention. As a result, this initiative has made strides in enhancing healthcare accessibility within underserved regions of Rwanda, where the availability of healthcare infrastructure's limited (Hansen et al. 2016).

SMS-Based Vaccination Reminders in India

In India there have been efforts to improve child vaccination rates through the use of SMS based reminder systems. Parents receive text messages reminding them of vaccination appointments, which helps to reduce instances of missed vaccinations and ultimately enhances immunization coverage. This initiative has proven to be effective, in safeguarding child health by preventing diseases that can be prevented through vaccines (Sahni et al., 2019).

Mobile-Based Maternal Health Education in Bangladesh

The MAMA (Mobile Alliance for Maternal Action) program, in Bangladesh is dedicated to providing women and new mothers with maternal health information through mobile phones. They receive SMS and voice messages that offer guidance on postnatal care, family planning and newborn care. This initiative has shown improvements, in child health outcomes by enhancing knowledge and encouraging healthy behaviors (LeFevre et al., 2014).

Mobile-Based Tuberculosis (TB) Treatment Support in Pakistan

In Pakistan there is a healthcare initiative called "mTIBB" that helps patients with tuberculosis (TB) using phones. Patients receive text messages to remind them about taking their medication, notify them about appointments and provide them with health education messages. This program has proven effective in improving the rates of adherence, to treatment and reducing interruptions in treatment, for TB patients ultimately contributing to control of the disease (Fatima et al., 2019).

Mobile-Based Data Collection for Disease Surveillance in Ghana

In Ghana the use of technology has been implemented to monitor diseases and gather data. Health workers utilize devices to report disease outbreaks and collect epidemiological information, in real time. This advancement has resulted in enhanced efficiency and precision in disease reporting allowing for responses, to outbreaks and improved management of health (Asemahagn et al., 2020).

Mobile-Based Antenatal Care in Tanzania

The Wazazi Nipendeni (Love me Parents) program, in Tanzania makes use of phones to offer mothers with important information about antenatal care and reminders for their appointments. Pregnant women receive text messages and phone calls that provide guidance on care, nutrition and getting ready for childbirth. This initiative has led to an increase in the utilization of healthcare services and played a role in promoting safer pregnancies and childbirth experiences (Lund et al., 2012).

Mobile-Based Diabetes Management in India

In India the mDiabetes initiative provides assistance to people, with diabetes by utilizing technology. Individuals receive text messages containing guidance, medication reminders and tips on monitoring their blood glucose levels. This program has resulted in enhanced management of diabetes adherence to treatment plans and improved control over levels, among those involved (Kumar et al., 2017).

Mobile-Based Family Planning Services in Kenya

In Kenya there is a platform called "iSikCure" that provides family planning services using phones. By using the app users can find out about methods, locate nearby clinics for family planning and even book appointments. This initiative has raised awareness, improved access to family planning services giving individuals the ability to make informed decisions, about their reproductive health (Nyongesa et al., 2019).

Mobile-Based Mental Health Support in Pakistan

In Pakistan a program called "UMANG" offers health assistance using phones. People can use it to find information, on how to manage stress to deal with depression and anxiety and even receive uplifting messages every day. This initiative has been successful in raising awareness, about health and providing help to those who are going through difficulties (Iqbal et al., 2019).

Mobile-Based Maternal and Child Health Monitoring in Malawi

The Chipatala Cha Pa Foni initiative, in Malawi enables community health workers and mothers to obtain child health information through a toll-free hotline. This program offers guidance on topics like pregnancy, caring for newborns and ensuring nutrition for children. It has played a role in enhancing the well-being of both mothers and children by increasing awareness and promoting access (Lori et al., 2012).

M-TIBA in Kenya

M-TIBA, an initiative, in Kenya has revolutionized the availability and affordability of healthcare through technology. Developed in partnership with Safaricom, a leading mobile network operator in Kenya and CarePay a company specializing in health financing technology M-TIBA serves as a platform that efficiently manages healthcare expenses and promotes inclusion. Users can easily deposit funds into their M-TIBA wallets, which are exclusively reserved for healthcare related costs. This versatile platform allows users to conveniently pay for healthcare services like consultations with doctors, prescriptions, diagnostic tests and hospital admissions making healthcare expenses more manageable. By integrating a network of healthcare providers into its system, M-TIBA ensures that users can easily locate and access quality services while promoting transparency in financial transactions within the healthcare sector. Particularly beneficial for populations with access, to traditional banking systems M-TIBA has played a crucial role in improving healthcare outcomes across Kenya (Safaricom, n.d.; CarePay, n.d.).

RapidSMS in Uganda

UNICEF has implemented a messaging system known as RapidSMS, which's an open-source platform used in Uganda to improve the collection and reporting of healthcare data. This innovative mobile technology allows healthcare professionals to exchange real time health information via text messages greatly enhancing the efficiency of data transmission, in the healthcare sector. In Uganda RapidSMS has been successfully utilized for healthcare purposes such as monitoring disease outbreaks, tracking vaccine distribution and monitoring child health indicators. By streamlining data collection and reporting procedures RapidSMS has played a role, in facilitating decision making processes improving healthcare services and effectively addressing public health challenges in Uganda (UNICEF Uganda, n.d.).

FrontlineSMS in Haiti

FrontlineSMS has been instrumental, in enhancing healthcare in Haiti. Following the earthquake in 2010 FrontlineSMS played a role in coordinating relief operations and disseminating lifesaving information to survivors. Over the years FrontlineSMS has successfully facilitated mHealth initiatives, such as enhancing health monitoring, promoting health education and providing healthcare access, to individuals residing in remote regions (FrontlineSMS, 2023; World Health Organization, 2023).

These examples demonstrate the variety of mHealth initiatives, in developing nations. Each of these initiatives tackles healthcare obstacles and enhances health outcomes, by utilizing mobile technology in innovative ways.

Here are some statistics on the use of mobile-based health applications in developing countries:

- As of 2021, there were over 175,000 mobile health (mHealth) apps available globally, many of which are targeted towards users in developing countries (World Health Organization, 2021).
- In low- and middle-income countries, the adoption of mHealth apps has been growing rapidly, with an estimated 1.7 billion smartphone users as of 2020 (GSMA, 2020).
- A 2019 survey found that 58% of respondents in developing countries reported using a mobile app for health purposes, compared to 33% in developed countries (Poushter & Oates, 2019).
- In India, there were over 100 million users of mHealth apps as of 2021 (Statista, 2021a).

- In India, Popular apps include Practo, 1mg, and Medlife for telemedicine, medicine delivery, and health information (Aithal & Aithal, 2018).
- 40% of Kenyan adults used mobile health services in 2019 (Kos et al., 2020).
- M-TIBA is a popular mobile wallet and health financing platform with over 2 million users in Kenya (M-TIBA, 2020).
- 30% of Nigerians used mobile health services in 2018 (GSMA, 2018).

CHALLENGES AND BARRIERS

Some of the major challenges and barriers of mHealth in developing countries are described below.

Limited Infrastructure

In developing nations there exists a lack of electricity and network connectivity, particularly, in rural and distant regions. This poses a challenge to the effective utilization of technology in healthcare (Tomlinson et al. 2013).

Digital Divide

Access to technology remains unequal in developing countries with marginalized communities facing availability of smartphones and mobile data. This disparity, in access worsens healthcare inequalities (Meurs et al., 2019).

Data Security and Privacy

There are concerns regarding the security and privacy of health data when it is collected and transmitted through devices. It is of importance to safeguard the confidentiality and integrity of information (Aranda-Jan et al., 2014).

Regulatory Challenges

In developing countries there might be a lack of defined regulations when it comes to mHealth applications and services. This can create uncertainty regarding the ethical considerations associated with delivering healthcare through technology (Fernandez-Luque & Bau 2015).

Healthcare Workforce Training

In order to make the most of technology in healthcare it is important for healthcare workers to receive training, on how to use it. Training programs are essential to ensure that healthcare professionals have the skills to effectively utilize the tools (Labrique et al., 2013).

Sustainability and Funding

Sustainable funding options, for mobile health initiatives are frequently insufficient. Long-term banking and financial support needed in sustaining operations and achieving significant impact (Labrique et al., 2013).

Cultural and Language Barriers

Mobile health interventions might not take differences into account without accessible in local languages, which could reduce their effectiveness among diverse populations.

Health Literacy

In cases, among patients residing in rural regions there may be individuals with limited knowledge, about health matters who face challenges when it comes to comprehending and utilizing mobile health apps efficiently.

Technical Support and Maintenance

Mobile devices and applications often need assistance and upkeep which can pose difficulties, in situations where resources are limited.

Resistance to Change

Healthcare professionals and individuals seeking care might exhibit reluctance, towards embracing technologies resulting in a gradual uptake and restricted effectiveness.

Interoperability

It is crucial to ensure communication and data sharing, among mobile health systems, which can become complicated especially when dealing with different platforms and devices.

Data Accuracy and Reliability

Health information gathered through devices may contain inaccuracies particularly if it is collected by individuals, without healthcare expertise or in areas, with insufficient resources.

ADVANTAGES AND BENEFITS

Mobile technology has brought benefits and advantages to healthcare in developing nations in areas where access, to traditional healthcare infrastructure is limited. Here are some of these advantages:

Increased Access to Healthcare Services

Mobile technology plays an important role, in enabling individuals residing in underserved regions to conveniently access healthcare information, seek consultations and avail of essential services. It effectively bridges the divide, between healthcare providers and patients (Labrique et al., 2013).

Telemedicine and Remote Consultations

Telemedicine has become increasingly popular, with the rise of apps and platforms. It offers patients the convenience of consulting with healthcare professionals which's particularly beneficial, for managing chronic conditions and follow up care (Mars and Scott 2016).

Health Information Dissemination

Mobile applications and SMS are widely utilized to distribute health related information, including tips on preventing diseases, reminders for taking medications and schedules for vaccinations. This greatly contributes to raising awareness about health issues (Free et al., 2013b).

Data Collection and Management

Mobile technology enables the real time collection of healthcare data, which enhances disease surveillance, helps monitor outbreaks and supports decision making based on evidence (Labrique et al., 2013).

Point-of-Care Diagnostics

Mobile devices have the capability to be equipped with tools transforming smartphones into laboratories. This plays a role in facilitating disease diagnosis and early intervention (Pai et al., 2012).

Health Worker Training

Mobile platforms provide training modules and resources to enhance the skills and knowledge of healthcare professionals those working in rural areas (Agarwal et al., 2015).

Supply Chain Management

Mobile technology is effective in monitoring and overseeing the supply chain of medications and vaccines guaranteeing their accessibility even in remote regions (Larson et al., 2016).

Behaviour Change Communication

Mobile applications and text message campaigns are utilized to promote behaviour modifications specifically focusing on promoting habits such as family planning, maternal and child health, and nutrition (Free et al. 2013b).

Cost Reduction

Mobile health interventions are frequently found to be economically viable alleviating the strain on healthcare systems and individuals (Mars and Scott 2016).

Research and Data Analytics

Healthcare data generated through mobile devices can be utilized for research and epidemiological studies contributing to the comprehension of disease patterns (Pai et al., 2012).

Empowering Patients

Mobile technology has provided patients with the ability to access their health records and play a role in making decisions, about their healthcare (Labrique et al., 2013).

Emergency Response and Disaster Management

Mobile devices play a role, in emergency situations by facilitating communication, coordination and allocation of resources during times of disasters and crises (Agarwal et al., 2015).

OPPORTUNITIES AND FUTURE DIRECTIONS

Mobile technology has opened up a world of possibilities in healthcare in developing countries. There are opportunities and exciting prospects, for the future that we can explore. Here are some of them:

Telehealth Expansion

The use of technology to extend telehealth services presents an opportunity to enhance healthcare access, in underserved regions. This can result in availability of consultations and specialized care for individuals residing in these areas. Looking ahead it is crucial to expand the telehealth infrastructure and services so that they can reach a vast number of populations. Additionally there should be an expansion, in the variety of services offered through telehealth. This way more people will benefit from healthcare regardless of their location (ITU, 2020).

Mobile Health Records and Data Management

The use of mobile health records and data management systems has the potential to enhance healthcare coordination to facilitate the sharing of information and improve decision making among healthcare providers. A promising approach involves integrating mobile health records into health information systems while prioritizing interoperability, data security and privacy enhancement (Labrique et al., 2013).

Remote Monitoring of Chronic Conditions

Mobile technology presents an opportunity for the real time monitoring of conditions, like diabetes and hypertension enabling patients and healthcare providers to effectively manage these health issues. Looking ahead there is a direction towards the development of devices and sensors that allow for continuous health monitoring as well as the expansion of remote monitoring programs (Kumar et al., 2017).

Health Education and Behaviour Change

Mobile apps and text messaging services have the potential to enhance health education, prevent diseases and encourage changes, within communities. A promising approach is to customize health education materials according to language requirements while utilizing artificial intelligence, for personalized health recommendations (Free et al., 2013a).

Mobile-Based Maternal and Child Health

Mobile technology has the potential to enhance child health in many ways. It can provide access, to information, on prenatal care, vaccination schedules and monitoring the growth of children. Looking ahead there is a need to strengthen existing child health programs by incorporating interventions and providing additional support from community health workers (Lund et al., 2012).

Mobile-Based Diagnostics and Point-of-Care Testing

Mobile technology presents an opportunity to accelerate the process of diagnosing and conducting tests, for diseases thereby aiding in detection and treatment. Looking ahead it is essential to focus on the development of devices that can be easily accessed in remote areas (Drain et al., 2014).

Mobile-Based Vaccine Distribution and Tracking

Mobile technology presents an opportunity to enhance the distribution and monitoring of vaccines thereby ensuring their accessibility to marginalized and remote communities. To achieve this we can consider implementing vaccine tracking systems through applications and employing SMS notifications as reminders, for individuals regarding vaccination schedules (Githinji & Noor 2016).

Mobile-Based Drug Supply Chain Management

There is a potential for technology to improve the management of drug supply chains ensuring that essential medications are always available and reducing instances of stockouts. Moving forward it would be beneficial to introduce mobile based systems, for managing drug inventory and incorporating technology to enhance transparency (Bhattacharya et al., 2017).

Mobile-Based Mental Health Support and Teletherapy

There is a chance to tackle the increasing health issues, in developing nations by expanding the availability of mobile based health services. These services can include teletherapy and various forms of support. Looking ahead it would be beneficial to focus on the development of mental health apps and provide training for mental health professionals, in teletherapy (Kuhn et al., 2014).

Mobile-Based Maternal Mortality Reduction

Mobile technology has the potential to play a role, in lowering maternal mortality rates by granting women access to emergency services, health related information and transportation. To move forward it is essential to focus on broadening the availability of mobile based emergency response systems, for health while simultaneously enhancing transportation networks (Abimbola et al., 2016).

Mobile-Based Health Insurance Enrollment

The use of technology has the potential to make health insurance enrollment and premium payments easier, which can help extend coverage to populations that currently have access. It would be beneficial to focus on promoting health insurance schemes that are based on platforms and improving peoples understanding of healthcare financing. This can contribute to literacy in the healthcare sector (Kutzin et al., 2016).

Mobile-Based Research and Surveillance

Mobile technology plays a role in advancing research and disease surveillance by enabling early detection and prompt response to disease outbreaks. Moving forward it is essential to focus on enhancing mobile based research networks and developing the capability, for real time data analysis (Wesolowski et al., 2016).

The possibilities and future paths emphasize the impact that mobile technology can have on healthcare in developing nations. It opens up avenues for access to healthcare, delivery of services and overall health outcomes.

CONCLUSION

Mobile technology offers a ray of hope in the field of healthcare delivery, in developing countries. Its ability to bridge gaps in access improve healthcare outcomes and enhance service quality is truly remarkable. As we have explored, mobile technology opens up opportunities such as expanding telehealth services enhancing health tracking and vaccination efforts and providing health support. Despite facing challenges like infrastructure and regulations, the future of healthcare technology in developing nations looks promising. By collaborating with governments, healthcare providers, tech innovators and global organizations and working together diligently we can unlock the potential of technology to create fairer, patient centered healthcare systems. It is our responsibility as technology continues to advance to ensure that these innovations benefit underserved communities and ultimately lead to improved well-being and brighter futures for individuals in developing countries. Mobile technology is not a tool; it serves as a catalyst for change, in healthcare that empowers nations to achieve health outcomes for their citizens.

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EVOLUTION OF THE NASHVILLE HEALTHCARE INDUSTRY CLUSTER

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ABSTRACT

While healthcare services have driven the development of different sectors of industry clusters, little attention has been paid to healthcare services as an industry cluster. This study analyzes the healthcare industry's evolution in the Nashville Metropolitan Statistical Area (MSA) through the framework of an industry cluster. The cluster evolution is evaluated by analyzing the presence of clustering antecedents and the regional economic benefits through economic data collected from 2004 through 2022.

Clustering antecedents are found in the Nashville healthcare industry (critical companies tied to each other economically surrounded by competing and cooperating companies, local research organizations, university-supported specialized and non-specialized labor pools, an entrepreneurial funding environment, and a commitment by either a local government or industry champion). We conclude that the healthcare industry in the Nashville MSA qualifies as a cluster and has provided increasing economic benefits to the region over the last 18 years.

The healthcare cluster has contributed significant jobs, business revenue, personal income, and state/local taxes to the regional economy, which has only grown over the study period. The number of healthcare establishments has doubled, providing an 80% increase in direct employment within the sector. Direct generated personal income improved by 106% from 2004 inflation-adjusted dollars, and business revenue injected into the regional economy increased to $36.8 billion, representing a 98% increase from 2004 inflation-adjusted dollars.

Industry clusters generally require a catalyst to form and sustain. In the case of the Nashville Healthcare Industry Cluster, uncharacteristically, the catalyst has not been a government entity but a local membership trade association serving as an industry champion (The Nashville Health Care Council - NHCC). The NHCC has supplemented the typical governmental role in developing industry clusters (e.g., government infrastructure development for logistics clusters) and has been a driving force facilitating networking, collaboration, and development, contributing to a self-sustaining entrepreneurial environment supported by venture capital and local universities providing specialized and nonspecialized labor forces.

This study identifies the Nashville MSA Healthcare Industry as an industry cluster that has provided significant benefits to the regional economy over the last 18 years. It also identifies the NHCC as the driving force behind developing an environment conducive to industry clustering. The success of the Nashville Healthcare Industry Cluster is supported by at least two other regional areas replicating the model with a Health Care Council organization.

INTRODUCTION

Industry clusters have been researched since 1920, when Alfred Mitchell analyzed three conditions conducive to cluster development (Mitchell, 1920). The three criteria identified by Mitchell are labor availability, the existence of specialized suppliers, and the possibility of external “spillovers” (knowledge sharing). Since 1920, there has been much research to refine the cluster definition and provide causes and incubating factors in which industry clusters develop (Isbasoiu, 2006).

Healthcare services have been viewed as a driver of forming and sustaining nonhealthcare industry clusters as a realized benefit in improving community health for the sizeable supporting workforce required. However, healthcare services as clusters have received less attention in the literature, yet there is evidence that various industry participants across multiple verticals can cluster, assuming a driving and instigating force exists. One such example is the healthcare industry in the Nashville Metropolitan Statistical Area (MSA). The Nashville MSA is home to more than 46 major public and private healthcare companies. In addition, seven of the nation’s 15 leading for-profit acute care hospitals and nursing management companies, accounting for approximately 34 percent of the investor-owned hospitals in the United States, are headquartered within the Nashville MSA (Arik and Devi, 2023).

In this study, we seek to analyze the locating of companies from various healthcare verticals within the Nashville MSA in the last 18 years, forming a significant healthcare cluster. We analyze the cluster through the lens of industry cluster development criteria, demonstrating that while less structured than examples of other industry clusters (logistics, biopharmaceutical, financial, or medical device), the healthcare environment within the Nashville MSA qualifies as a cluster driven by a local membership association, The Nashville Health Care Council (NHCC), generating a considerable impact on the local and regional economy and the associated industry environment.

The paper is structured as follows. The next section discusses existing literature concerning industry cluster criteria and what makes an industry cluster, forming the basis of our analysis of the healthcare industry in the Nashville MSA. We then discuss the methodology and data used in the study, resulting in our findings. Finally, we present our conclusions and discuss the implications and limitations of this study.

LITERATURE REVIEW

The review of selected literature concerning industry clusters provides several defining criteria. Porter (1998) defined clusters as “geographically proximate groups of companies and associated institutions in a particular field, linked by commonalities and complementarities.” Subsequently, cluster definitions have been refined to include geographic and spatial clustering of economic activity, relationships between industry sectors, the presence of a central actor, cooperation, competition, and the role of social interaction (Jacobs and De Long, 1996). Rivera, Gligor, and Sheffi (2016) define industrial clusters as “groups of interrelated firms that cooperate and compete to create wealth within a certain geographical area.” Essentially, clusters need a critical mass of firms located in geographic proximity that are economically tied to each other along with significant financial resources for investment.

There is no agreement concerning a general theory or law of how clusters form (Isbasoiu, 2006). The conditions vary depending on the cluster's type, industry, and geography. However, some criteria have been discussed in the relevant literature. For example, Wolfe & Gertler (2004) propose that clusters can form around one or two critical firms that attract other companies over time. Clusters can also form due to public sector investment, such as research-intensive universities for knowledge-based industries or substantial infrastructure investment for logistics clusters. Another driving factor can be a strong commitment by either local government or an industry champion to provide "leadership, the vision, and the wear-with-all to make industry clusters happen" (Roberts, 1998).

Hallock, Thai, Peszynski, and Chhetri (2018) provided a literature review of the benefits of industry clusters that provide insight into cluster requirements. These authors discussed labor (availability of specialized and non-specialized labor, knowledge spillovers, and technology spillovers) and location or spatial (proximity, collaboration, and networking) as key cluster benefits. Realizing these benefits requires a strong specialized and non-specialized labor pool and an environment that helps initiate and support collaboration and communication opportunities to facilitate knowledge sharing.

While clusters provide regional economic benefits, they can also improve technological and operational innovation resulting from knowledge spillover (Cui, Wang, Xu, & Li, 2022). Various types of organizations, such as government agencies, research institutes, trade organizations, companies, and universities, can contribute to the relationship between regional development and the creation of innovative performance in industry clusters (Kim, Hwang, & Yoon, 2023). Clusters can provide mechanisms for sharing tacit knowledge or knowledge, skills, and abilities learned through experience. This knowledge-sharing occurs as employees shift between cluster members and move into the economic region from other areas (Cooke, 2002). The tacit knowledge-rich environment can also drive companies to locate within a cluster to gain or prevent the loss of such knowledge by retaining access to skilled workers and competencies (Sammarra and Belussi, 2006). Therefore, clusters can attract a highly skilled and knowledgeable workforce that attracts more companies that rely on these skills, further growing the cluster in a self-feeding cycle.

METHODOLOGY AND DATA

Our analysis is based on data collected for 2004, 2008, 2014, and 2022 concerning the healthcare industry in the Nashville MSA. The relevant objectives of this study are the analysis of industry cluster characteristics and the trends, scope, and impact of the healthcare industry cluster on the regional economy, the economic significance to the region of healthcare companies headquartered in Nashville, and the role of the Nashville Health Care Council in promoting the healthcare industry in the Nashville MSA.

The healthcare cluster includes core healthcare providers that provide services directly to healthcare consumers, such as

- Ambulatory Services
- Hospitals
- Nursing Care Facilities
- Physicians

Peripheral healthcare suppliers and supporting companies include related healthcare industries, such as management companies and biomedical research entities providing services to core healthcare providers or the specialized and nonspecialized workforce, such as

- Healthcare Management Organizations
- Consulting Organizations
- Colleges and Universities
- Research Organizations
- Public Health Organziations
- Medical Insurance
- Healthcare Manufacturing and Wholesalers,
- Pharmacies
- Drug Stores
- Ophthalmic Goods

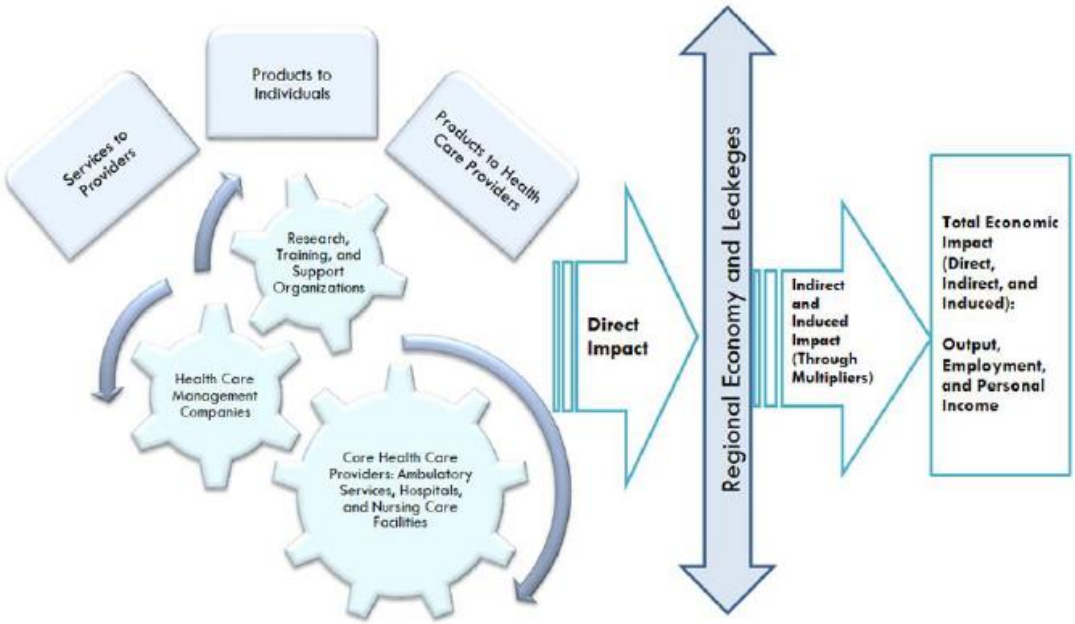
These entities have a direct impact on the economy through employment (total number of full-time employees), personal income (total reported pre-tax payroll), and business sales (total spending of the healthcare cluster to purchase goods and services in the associated economy). There is also an indirect impact referring to employment, business sales, or income generated by the interaction of local businesses with the healthcare industry cluster and by suppliers via business-to-business transactions. For example, a hospital purchases goods and services from local businesses for its operation. This hospital's spending in the local economy means additional jobs, business revenues, and personal income in other sectors. Induced impact refers to the employment, sales, and personal income generated in the local economy by employee spending (Arik and Devi, 2023).

The data used in this study to understand economic impact was collected from multiple sources and used to construct a time-series perspective on healthcare indicators, as detailed in the Appendix of Arik and Devi (2023). Additional data was collected from an NHCC member survey targeting 252 Nashville MSA organization members to understand the impact of the NHCC. The survey included company profile, company operations, and Nashville Health Care Council Impact. One hundred twenty-eight companies accessed the survey, but only 60 responses were usable, representing a response rate of 23.8 percent.

One way to quantify the economic impact of the cluster is to use a counterfactual approach, which removes the whole healthcare industry cluster from the economy and then measures the economic impact of the subtraction on the economy. The conceptual framework of how the cluster impacts the economy is included in Figure 1.

IMPLAN impact modeling software (a predictive model based on regional accounting matrices) was used to measure the impact of the core and peripheral. The IMPLAN model considered the direct employment, business sales, and income generated by the healthcare industry cluster and the additional or secondary impacts of all economic activity related to such employment and business sales. The indirect and induced effects of the healthcare subsectors were adjusted on each other within the healthcare industry cluster. The study assumed that IMPLAN regional purchasing coefficients (RPCs) represent the current situation, and the differences between 100 percent local purchase and the default model RPCs determine the leakages outside of Nashville. To avoid double-counting, the core healthcare providers were not allowed to stimulate the cluster's healthcare sector and other subsectors.

Figure 1: Conceptual Framework for Impact Analysis



Source: Authors

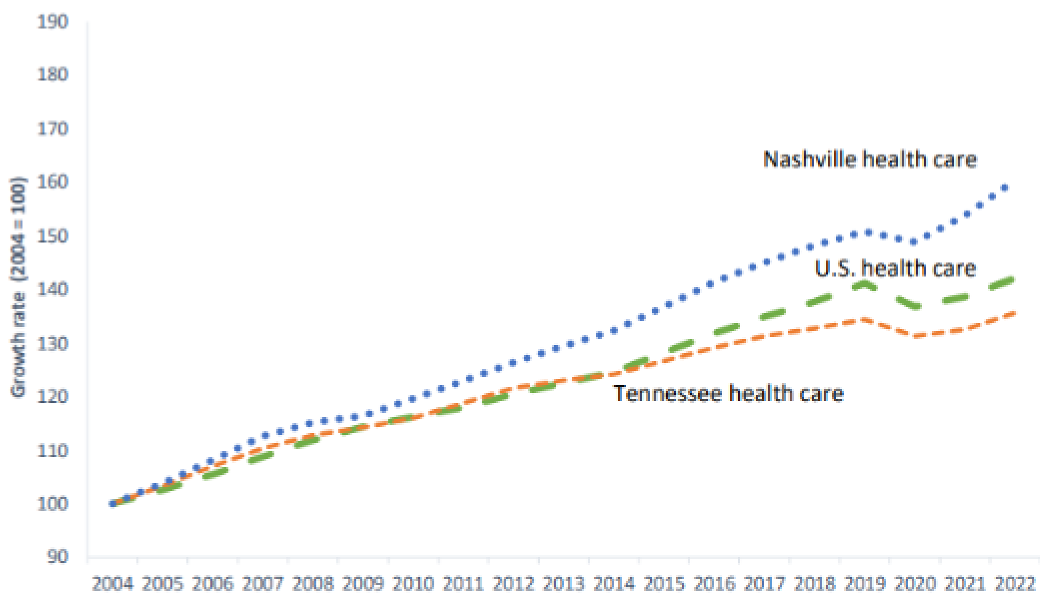
RESULTS

The Nashville MSA healthcare industry has grown significantly over the last 18 years, including companies, employment, and economic impact (refer to Table 1). This growth is significant to study because it has outpaced both Tennessee and national industry growth. One such example (Figure 2) is employment growth, which has outpaced both the Tennessee and national growth rates (Arik and Devi, 2023). Many factors contribute to this growth, including business climate, available venture capital, adequate labor supply, and other opportunities.

Table 1 Nashville MSA Healthcare Cluster Companies, Employment, & Economic Impact (Summary)				
Year	Nashville-Based Healthcare Establishments	Industry Cluster Direct Employment (# of Jobs)	Industry Cluster Generated Personal Income (inflation-adjusted to 2022 $ Billions)	Industry Cluster Direct, Business Revenue Injected into Economy (inflation-adjusted to 2022 $ Billions)
2004	2,237	94,346	$9.8	$18.6
2008	2,703	113,453	$8.2	$23.1
2014	4,027	125,918	$19.7	$28.6
2022	4,755	170,702	$20.3	$36.8

Source: Arik and Penn, 2006; Arik, 2010; Arik, 2015; Arik and Devi, 2023

Figure 2: Healthcare Employment Growth Trend: Nashville versus the U.S. and Tennessee U.S. and Tennessee



Source: Arik and Devi, 2023

Nashville MSA Healthcare Industry as a Cluster

The Nashville MSA healthcare industry supports a cluster definition based on multiple criteria, such as critical companies tied to each other economically surrounded by competing and cooperating companies supporting various components of the industry; research organizations and university-supported specialized and non-specialized labor pools; an entrepreneurial and robust funding environment; and a commitment by either a local government or an industry champion. (Arik and Devi, 2023). Nashville-based healthcare establishments have increased by 113% to 4,755 in 2022, demonstrating a clear trend toward company attraction to the cluster. In 2022, 17 publicly traded healthcare companies were headquartered in Nashville, and 46 major Nashville-based public and private investor-owned healthcare management companies. These companies represented a global reach across the healthcare industry.

Physical Clustering Linked by Commonalities and Complementarities

The initial impetus for the cluster dates back to the 1960s, with the location of three critical hospital companies in the Nashville area: Hospital Corporation of America (HCA), Hospital Affiliates International (HAI), and General Care Corporation. Each of these companies subsequently instigated hundreds of spinoffs, new companies, mergers, and acquisitions into all aspects of the healthcare industry (A History of Healthcare in Nashville, 2015), evolving into the existing complex network of healthcare cluster companies.

The strong network of healthcare companies and expertise now serves as a strong attractor to new competing, supporting, and complimentary entrants into the cluster. For example, the Center for Medical Interoperability opened its headquarters in Nashville in 2017. The center is a cooperative research and development lab founded by health systems to simplify and advance data sharing among medical technologies and systems. The main criterion for the center's location in Nashville was the proximity to major health systems (Landi, 2018).

Entrepreneurial Environment

The Nashville MSA is home to a robust entrepreneurial environment supporting industry innovation. Starting in the 1960s with the founding of one of the first multi-hospital systems (HCA) to the invention of the ambulatory surgery model credited to Surgical Care Associates (SCA) formed in 1985, the Nashville market has been a leader in healthcare innovation. Much of this entrepreneurial activity can be explained through the social/work network in the Nashville healthcare business community (Carr, Topping, Woodard, & Burcham, 2004). These authors show how an entrepreneur who enters a network establishes contact with multiple nodes (people and companies), providing additional information and lowering transaction costs. The increased entrepreneurial activity leads to more nodes and entrepreneurial activity; "healthcare entrepreneurship creates more healthcare entrepreneurship" (Carr et al., 2004). A strong venture capital fund structure underpins the entrepreneurial environment, contributing over $370 million in 2022, representing just over 26% of all venture capital activity in the region (Arik and Devi, 2023).

Labor and Public Sector Investment

The Nashville MSA supports the specialized and non-specialized labor supply with two private medical-focused universities, three public universities, four private universities, and an extensive network of smaller private colleges and public community colleges. The three public universities awarded over 8,100 Bachelor's and Master's degrees in the 2019-2020 academic year. (THEC, 2021), and the four private universities awarded just over 7,300 Bachelor's and Master's degrees in 2021. The largest private university is Vanderbilt, a major research and teaching hospital. Additionally, the University of Tennessee and Memphis University are just outside the MSA and supply the healthcare industry labor force.

Industry Champion

The Nashville Health Care Council (NHCC) is an industry association comprising over 300 member organizations catalyzing leadership and innovation (NHCC, 2023; Landi, 2018). This organization is the driving force facilitating networking and collaboration within the healthcare cluster. The NHCC supports leadership with two programs (Fellows Program and Leadership Health Care). The Fellows Program provides a customized curriculum for existing leaders to learn from peers leading top healthcare organizations of all sizes and geographies nationwide (NHCC, 2023). The Leadership Health Care program "provides members unique educational programs and networking opportunities." The initiative has a membership of more than 500 up-and-coming healthcare industry leaders from hundreds of organizations (NHCC, 2023). The organization provides additional collaboration and networking activities with various events throughout the year. The organization has achieved high levels of success and has served as a model for the Austin Healthcare Council and the Health Care Council of Chicago (Landi, 2018).

The NHCC member survey highlighted the impact of the organization on the cluster. Responding company CEOs indicated 25 ways the NHCC contributes to the entrepreneurial environment in the Nashville MSA. Of the responses, the six most common were networking, connecting players from all sides of the industry: connectivity is related to networking but is highly emphasized in the comments, collaboration, events organized by the Council, training-from the fellows program to other educational activities, and development of educational materials and resources for opportunities and challenges.

Members were also asked to provide three words to describe the contribution the Nashville Health Care Council makes to the growth of the healthcare industry in the Nashville MSA. The top six of the more than 50 distinct responses included collaboration, network, leadership, education, innovation, and connections. The survey responses provide evidence that the NHCC serves as a driving force in facilitating networking and knowledge sharing across the different sectors of the healthcare cluster in this region. While local government participates in cluster development through typical business attraction and retention activities, the NHCC is a key factor contributing to cluster growth.

Nashville MSA Healthcare Cluster Impact on the Regional Economy

This study found multiple indications of the positive impact of the Nashville MSA healthcare cluster on the regional economy. The impact has grown substantially. Employment is a critical factor for clusters. Healthcare clusters depend on a strong labor market to provide for specialized (medical, patient care, etc.) and non-specialized job roles (support, administration, etc.). Additionally, a critical mass of companies and employees is required to realize the "spillover" effect of knowledge sharing and innovation. The Nashville MSA healthcare cluster has experienced significant employment growth (Just over 80% in direct employment and 115% in direct, indirect, and induced employment).

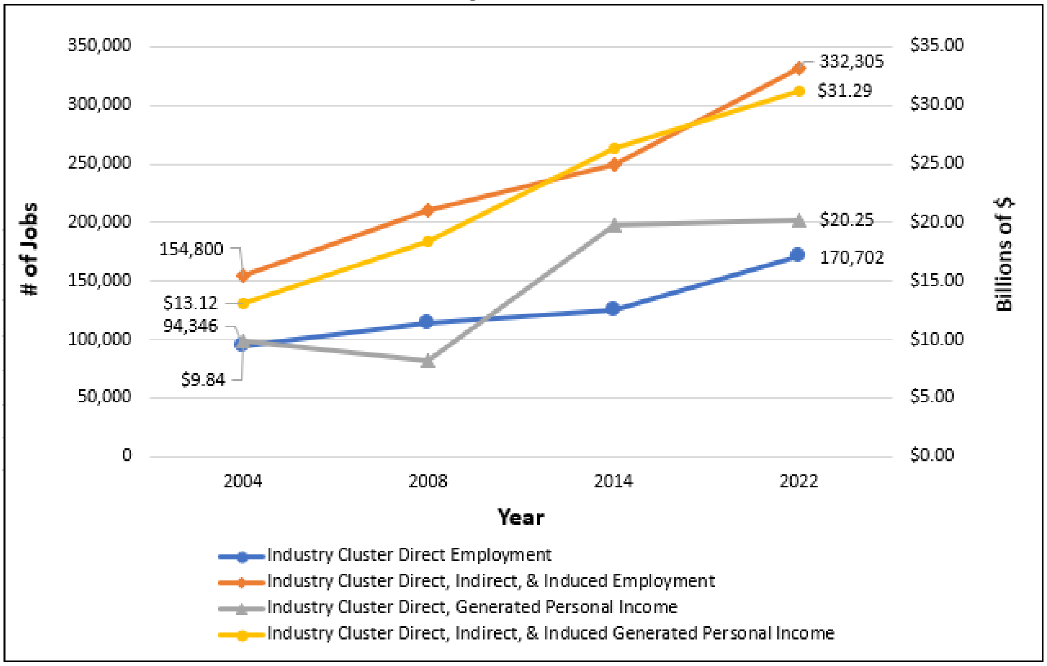
The cluster has also contributed significantly to personal income in the Nashville MSA. Direct personal income generated by the cluster adjusted for inflation to 2022 dollars has grown by nearly 106% from 2004 to 2022 to $20.25 billion (refer to Table 2 and Figure 3), representing 23% of the total personal income in the Nashville MSA.

Table 2
Nashville MSA Healthcare Cluster Employment and Generated Personal Income

Year	Industry Cluster Direct Employment (# of Jobs)	Industry Cluster Direct, Indirect, & Induced Employment (# of Jobs)	Industry Cluster Direct, Generated Personal Income (inflation-adjusted to 2022 $ Billions)	Industry Cluster Direct, Indirect, & Induced Generated Personal Income (inflation-adjusted to 2022 $ Billions)	Percent of the Nashville MSA's total personal income
2004	94,346	154,800	$9.8	$13.1	18%
2008	113,453	211,059	$8.2	$18.4	22%
2014	125,918	249,345	$19.7	$26.3	26%
2022	170,702	332,305	$20.3	$31.3	23%

Source: Arik and Penn, 2006; Arik, 2010; Arik, 2015; Arik and Devi, 2023

Figure 3: Nashville MSA Healthcare Cluster Employment and Generated Personal Income Inflation Adjusted to 2022 Dollars



Source: Arik and Penn, 2006; Arik, 2010; Arik, 2015; Arik and Devi, 2023

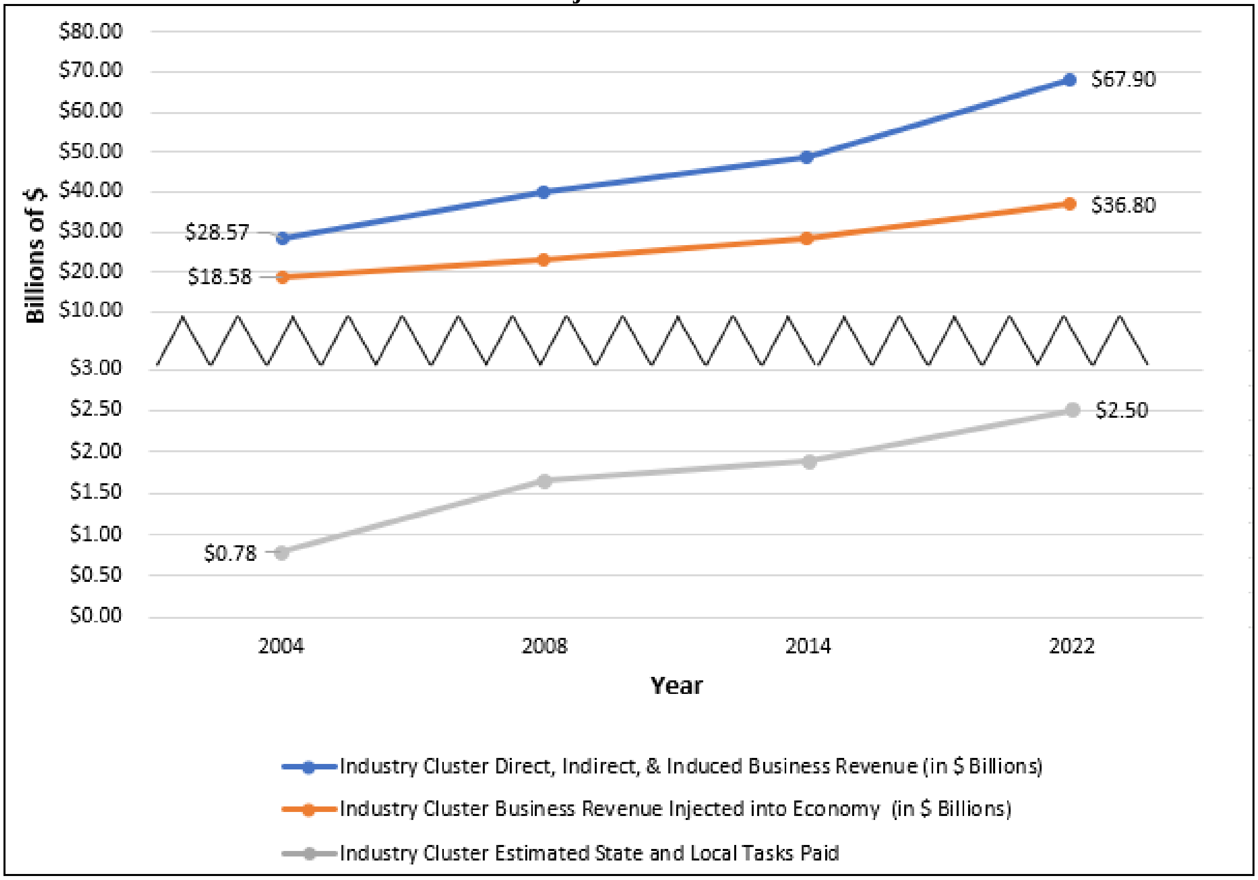
Turning to the economic impact on the surrounding region, we also find significant evidence of growth. The cluster generated over $67 billion of business revenue in 2022, representing a 138% increase over 2004 (inflation-adjusted to 2022 dollars). The cluster has also contributed over $2.50 billion in state and local tax revenue in 2022. Total direct, indirect, and induced business revenue grew from $28.57 billion in 2004 (inflation-adjusted to 2022 dollars) to $67.90 billion in 2022 (refer to Table 3 and Figure 4).

Table 3
Nashville MSA Healthcare Cluster Economic Impact

Year	Industry Cluster Direct, Indirect, & Induced Business Revenue (inflation-adjusted to 2022 $ Billions)	Industry Cluster Business Revenue Injected into the Economy (inflation-adjusted to 2022 $ Billions)	Industry Cluster Estimated State and Local Tasks Paid (inflation-adjusted to 2022 $ Billions)
2004	$28.6	$18.6	$0.8
2008	$40.1	$23.1	$1.7
2014	$48.6	$28.6	$1.9
2022	$67.9	$36.8	$2.5

Source: BERC Health Care Industry Nashville MSA Analysis, 2005, 2010, 2015, and 2023

Figure 4: Nashville MSA Healthcare Cluster Economic Impact
Inflation Adjusted to 2022 Dollars



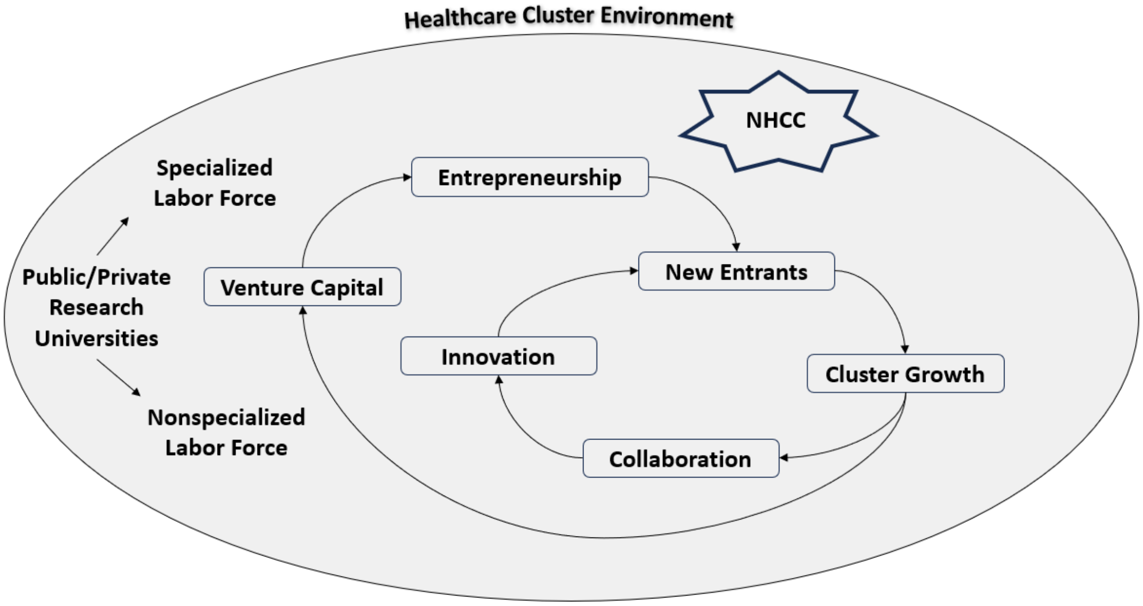
Source: BERC Health Care Industry Nashville MSA Analysis, 2005, 2010, 2015, and 2023

IMPLICATIONS AND LIMITATIONS

Industry clusters are important to a region's economic growth and participating companies' associated performance. The Nashville MSA healthcare cluster fosters collaboration and innovation, attracting new entrants. Actual and potential growth, in turn, attracts venture capital that contributes to a robust entrepreneurship environment, further attracting new entrants. The NHCC serves as the conduit and catalyst through actions and programs that cultivate knowledge/technology sharing, collaboration, and networking as part of the cluster environment, adding to public and private university support of the specialized and nonspecialized labor force (refer to Figure 5, illustrating the components of the cluster environment). These components combine to contribute to the growth and sustainability of the healthcare cluster.

The positive historical impact of the Nashville MSA healthcare cluster on the regional economy implies that sustained performance and growth of the cluster contribute significantly to the development of the surrounding economy. As the cluster grows, so will the impact of expanding employment, personal income, and tax revenues. As discussed above, successful entrepreneurship results in more entrepreneurship. Likewise, the knowledge sharing through company communication and collaboration fostered by the cluster industry champion, in this case, the NHCC, grows the innovation-rich culture, resulting in more companies desiring to locate within the cluster. In the end, a self-sustaining cycle of growth is established.

Figure 5: Nashville Healthcare Cluster Environment



The implications are significant for regions with a high presence of healthcare industry companies. Colocation and collaboration can grow organically, but the NHCC provides an example of how growth can be fostered by focusing on the critical characteristics of industry clusters, specifically collaboration and networking.

In exploring the Nashville MSA healthcare cluster, this paper did not analyze other potential healthcare clusters following the same path. Further research can review the development of the healthcare industry in Austin and Chicago to evaluate the impact of similar industry champion organizations, comparing these regions to Nashville's success. In this manner, the model can be validated and serve as a roadmap for future potential healthcare clusters.

CONCLUSIONS

Healthcare clusters are less researched than other industry clusters, but their impact on regional economies and healthcare services is significant. This study shows the evolution of the economic impact of the healthcare cluster on the Nashville MSA economy through the growth of jobs, personal income, business revenue, and state and local tax contributions to local governments. Our contribution to existing knowledge is identifying the NHCC's role in developing and supporting an environment conducive to cluster growth and sustainability. Other industry clusters, such as logistics clusters, rely extensively on local and state government funding for infrastructure and other environmental development. While supported by local and state governments through favorable incentives, Nashville's healthcare cluster success is more strongly driven by a robust industry organization dedicated to the service of its participating members.

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