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UCSF Health Workforce Research Center on Long-Term Care

Research Report

The Impact of Emerging Technologies on Long-Term Care & the Health Workforce

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Executive Summary

Background

Rapidly emerging technological advances have the potential to mitigate a portion of the rising workforce demand due to an aging population and the increasing chronic disease burden. They may help people remain in their homes, assist long-term care (LTC) facilities in their efforts to care for the aging, and/or improve home health and home care worker recruitment, retention, and efficiency.

Little is known about how technological advances will affect the size, skills, and training needs of the workforce required to care for aging Americans. This report addresses this knowledge gap with a scan of available technologies currently or soon to be in use for and by consumers and/or LTC workers; it also assesses which of these may facilitate, replace, or enhance recruitment, training, and retention of the LTC workforce.

Methods

This qualitative study began in January 2018 with an environmental scan of peer-reviewed publications, gray literature, conference materials, and company websites with online demonstrations of emerging health technologies with potential impact on the care of older persons or the LTC workforce, whether situated in the home of a client or in an LTC setting. This scan was repeated 5 times over a period of 5 months, ending in May 2018. A three-member research team independently reviewed all of the collected information and created a taxonomy of technology categories based on the products sold by a total of 115 companies. The team then selected roughly one company in each category to contact for an online telephone interview.

Results

Interviewees generally agreed that technology will not fully replace the direct care workforce in the near future. While robotic solutions that connect to

home automation systems and family members continue to be developed and improved, they are not likely to mitigate the workforce shortage.

Technology solutions that facilitate the workforce were more prominent in our research findings, including remote monitoring systems, enhanced documentation tools, wearable communication tools, and education tools.

We also found technology that addressed workforce recruitment, retention, and staffing efficiency. For example, predictive analytics are used to identify candidates best suited for certain long-term care positions, which is beneficial to both initial recruitment as well as long-term retention. Other techniques to improve retention include more choice in shift scheduling, work location, and clientele. Staff efficiency was improved by real-time location tracking for quick assistance in emergent situations and analysis of those location patterns for enhanced long-term insights.

Potential barriers to widespread adoption of an expanding number of new products and services include consumer concern about privacy and the security of health data, usability, and cost; potential differences in product specificity or acceptance among diverse racial and ethnic groups; and lack of internet connectivity in many rural areas.

The development, implementation, and evaluation of technology to support the aging and chronically ill, their families, and the long-term care workforce should be, but is often not, developed in partnerships between researchers and the technology industry. Unfortunately, all too often, products are created without a user-centered design, which considers the needs and characteristics of the user.

Most of the products and services we researched billed the cost of their services direct-to-consumer or direct-to-facility. There was little to no reimbursement by third-party payers (e.g., Medicare, Medicaid, or private insurers), and private pay only services will be limited in adoptability if they are only available to those who can afford to pay.

Conclusions

Long-term care technology is a growing industry with capital investments made in many new products and services developed each year. However, there is little research on which technologies will have the greatest potential

impact on the workforce that is providing direct care. Reimbursement from federal and private payers is minimal to date, yet demand for government payment may grow as use of these technologies grows in the long-term care sector. Payment issues aside, there is opportunity for emerging LTC technologies to enhance quality of life for patients, assist friend/family caregivers, and improve workforce efficiencies.

The Impact of Emerging Technologies on Long-Term Care & the Health Workforce

Background

By 2030, people 65 and older are projected to account for 20 percent of the US population.[1] Survey data indicate that 87 percent of Americans age 65 or older prefer to age in place, at home or in their community.[2] Aging in one's home can present many challenges, including the need for safety, ongoing clinical monitoring, communication with family and the healthcare team, and social isolation.

Rapidly emerging technological advances hold great potential for older people and their caregivers in navigating the social, cognitive, and physical changes associated with aging.[3] These technological advances have the potential to substantially alter workforce needs and potentially mitigate a portion of the rising workforce demand due to an aging population and the increasing chronic disease burden.[4,5]

Cutting-edge products and services may help people remain in their homes or assist long-term care (LTC) facilities in their efforts to care for the aging via technology that can perform a variety of functions and that is person-centered.[6] Examples of such functions include tracking and predicting patterns of activities of daily living (ADL), collecting data through sensors to reduce or predict the risk of falls, and providing social communication and ongoing contact with family members or paid home health and home care workers. Technology focused on LTC settings may have the additional effect of improving home health and home care worker recruitment and retention, as well as the general efficiency of this work.

Previous work has been undertaken to examine implementation, access, outcomes, and acceptance of technology aimed at older adults.[7-9] In some cases, the evidence for the use of technology in aging services is strong, such as using remote monitoring to control chronic conditions.[10] But for many technologies, there is a lack of high-quality research supporting their clinical benefits and cost-effectiveness.[11] In addition, there are barriers to the adoption of assistive technology, including lack of awareness, privacy and

security concerns, usability, compliance with use, computer literacy, provider training and workflow, and interoperability.[11]

Little is known about how technological advances will affect the size, skills, and training needs of the workforce required to care for aging Americans. This report, in part, addresses this knowledge gap, with a scan of available technologies currently in use for and by consumers* or LTC workers and assesses which of these may facilitate, replace, or enhance recruitment, training, and retention of the LTC workforce.

Study Research Questions

- What types of technologies have been developed with an application in long-term care?
- How might various categories of technology in long-term care affect the existing and future workforce needs?
- What are some specific examples of the impact of technology on the long-term care workforce?

Methods

This qualitative study began in January 2018 with an environmental scan of peer-reviewed publications, gray literature, conference materials, and company websites with online demonstrations of emerging health technologies with potential impact on the care of older persons or the LTC workforce, whether situated in the home of a client or in an LTC setting. This scan was repeated 5 times over a period of 5 months, ending in May 2018. A three-member research team independently reviewed all of the collected information and created a taxonomy of technology categories based on the products sold by a total of 115 companies. Taxonomy development is a formal system for classifying complex phenomena according to a set of common conceptual domains.[12] This method aligned well with emerging technologies because the myriad products and services we found in the

*Please note that throughout the report, the terms consumer, patient, client, and resident are used interchangeably to refer to the aging and/or the chronically ill (i.e., people being assisted by technologies and/or are receiving care); the use of a specific term is dependent upon the context in which it is being used.

environmental scan had elements that could be categorized according to similar uses or targeted needs in long-term care. Evernote® was used to store and organize information about specific technology companies. To create the taxonomy, each member of the research team accessed their own copies of the Evernote® file and independently created technological categories, or domains, and assigned each product or service to a particular domain(s). Then, the research team compared their individual taxonomies and developed consensus on the categories.

As noted, the environmental scan identified 115 companies with products or services that met our criteria. The research team's taxonomy consensus placed these companies/technologies into 14 categories: robots, EHR interoperability, education, remote monitoring, wearables, family caregiver support, online care management, home-to-clinic communication, staffing and recruitment, facility/home health management, documentation, patient-employer engagement, alarms and alert systems, and assisted living (Figure 1).

Figure 1. Taxonomy of Technologies

The team then selected roughly one company in each category, selecting companies that appeared to be leaders in their categories and/or offer the most comprehensive services, all while also seeming to impact the workforce, to contact for an online telephone interview. (There was some overlap between categories.) IRB approval was obtained and 16 requests for

interviews were sent; 11 interviews were completed with US-based companies, and two were conducted with international companies. The interviewee(s) at each company were either the CEO, COO, and/or marketing/project developer. At the request of some of the companies, a few interviews were conducted with a group of 2-3 of the company's senior leaders. Interviews were of 1-hour duration and were recorded. Each member of the interview team took notes during the interview. Table 1 shows the names of each of these companies, which taxonomy category (or categories) applied to them, the targeted customer(s), the sites in which products were used, and their application to the workforce. Summaries of each of these companies can be found in the Appendix.

Table 1. Company & Product Details

Company Name	Taxonomy Category	Targeted Customer(s)	Sites Used In	Workforce Application
Alma's House	Remote Monitoring; Alarms/Alert Systems	Individuals with dementia/aging	In-home; Living Communities	Reduce amount of in-person caregiver intervention(s)
Arena	Staffing & Recruitment	Health Care Facilities (acute-care hospitals; long-term care facilities; academic medical centers)	Health Systems; Hospitals; Assisted Living	Enhance hiring
Canary Health	Education; Family Caregiver Support; Online Care Management	Diabetics; Individuals with chronic disease; Caregivers	In-home	Provide caregiver support
CarePredict	Wearables; Assisted Living; Alarms/Alert Systems	Long-term care facilities; Individuals requiring home care	Assisted Living; Memory Care; Assisted Living; Retirement Communities; In-home	Provide more information to caregivers/staff
ClearCare	Facility / Home Health Management; Online Care Management	Home Care Agencies	In-home	Provide more information to caregivers/staff/ healthcare providers

Intuition Robotics (ElliQ)	Robots	Individuals aging at home	In-home	Reduce amount of in-person caregiver intervention(s)
Embodied Labs	Education	Healthcare workers; Long-term care/senior care facilities; Hospital systems; Health professionals	VR lab	Enhance understanding of patient condition/situation
GrandCare®	Home-to-Clinic Communication; Remote Monitoring	Individuals aging at home	In-home	Reduce amount of in-person caregiver intervention(s); improve communication with patient
Honor	Staffing & Recruitment	Non-medical home care agencies	In-home	Improve caregiver experience
La Valeriane®	Documentation; Online Patient-Employer Engagement	Individuals aging at home; Healthcare professionals; Home Care Agencies	In-home; Adult day care centers; Assisted Living; Nursing Homes; Independent Living	Enhance understanding of patient condition/situation
LifePod™	Robots	Individuals aging at home	In-home	Reduce amount of in-person caregiver intervention(s)
UnaliWear™	Wearables; Alarms/Alert Systems	Individuals aging at home	In-home	Reduce amount of in-person caregiver intervention(s)
VisibleHand	Documentation; EHR Interoperability	Skilled Nursing Facilities; Hospitals; Addiction Treatment Centers	Skilled Nursing Facilities; Hospitals; Addiction Treatment Centers	Provide more information to caregivers/staff/ healthcare providers

Analysis

Interview notes and recordings were downloaded into Dedoose® qualitative and mixed methods research software and coded separately by each member of the research team. The research team then examined and reached consensus on a thematic coding and data analysis strategy,[13] which involved

regular meetings to discuss themes identified from reviewing and coding the transcripts separately. An iterative process of reviewing the interview notes continued until key themes emerged.

Results

The research team identified the following key themes:

Contextual Development of the Companies

Professional Background

The interviewees came from an array of professional backgrounds, including academia, business, engineering, marketing, healthcare, education, and/or government and policy. Most had spent significant amounts of time in the workforce within their particular industry. Several also described substantial experience with the technology industry, as many had started and sold other technology companies. However, those prior experiences were not always related specifically to the healthcare technology industry.

Personal Experiences

Over half of those interviewed (7) indicated that their motivation for starting their company stemmed from observing the struggles of aging family members or the family of close associates. These interviewees often commented on specific problems or inefficiencies that they observed in healthcare concerning aging services and described their desire to remedy the problems with technology solutions.

Products & Services

Features of Products

Of the 13 companies interviewed, 8 products could send notifications to clinical and/or non-clinical staff, 8 products offered mobile technology features, 4 companies offered calendaring functions, 4 provided medication reminders, 3 companies pushed information/notifications to family members, 3 focused on or incorporated documentation tools, 3 companies used voice-first technology, and 2 had push-button features for easier/simplified data

input. One company utilized an assessment tool for ADLs/IADLs, and another incorporated dolls/toys/robotic animals for social comfort.

Types of Technologies

Of the 13 companies, 6 were strictly software companies. The remaining 7 incorporated element of both software and hardware. Of these 7 companies, most used hardware components made by other companies, but had their own proprietary software, with one exception – a company that incorporated its proprietary hardware and software components.

Software

Several companies emphasized their use of sophisticated computer science and statistical tools to achieve their goals. Two companies described using machine learning to help their technologies improve over time. Two other companies explained that artificial intelligence was crucial to their technologies. Another incorporated natural language processing.

Another two companies specified that despite using some of the above-mentioned tools their predictive models did not work well until they had captured a significant amount of data on the operations of specific, individual clients. Only once they had captured enough client-specific data could full model functionality be achieved. Until then, these companies rely on data from outside organizations because these data have been shown to be more reliable than human-reported information.

Hardware

Among the 7 companies that incorporated hardware elements, the incorporated hardware was most frequently used for sensing purposes. The devices varied, ranging from those that could detect falls to those that performed glucose readings. Five companies had already incorporated sensors into their product/service at the time of the interview. Another company had plans to incorporate sensors in the future. Other examples of hardware use included an Amazon Echo, a life-like (but not human-like) robot, and virtual reality headsets.

Aims of Products/Technologies

Each technology worked to address specific issues through a variety of means, and many technologies utilized several strategies to achieve their ultimate goal.

A little under half of companies (5) monitored health and activity measurements of their clients. Some companies used sensing devices to achieve this, while others used techniques such as enhanced documentation and assessment tools. By doing so, companies aimed to:

- Detect falls earlier (and contribute to quicker EMS response time)
- Gain a better understanding of individual client/patient ADL needs
- Track significant social and/or biometric changes that might signal a need for intervention by healthcare providers and/or family members
- Determine the effectiveness of previous interventions and inform new interventions
- Improve workers' understanding of residents' behavioral needs

Four companies focused on or incorporated predictive modeling to enhance workforce retention, patient/client safety, and/or behavior change. According to interviewees, predictive models are particularly useful because they are developed from volume-rich company/organization data. One interviewee stated the importance of using predictive models to anticipate problems rather than reacting after adverse events occur: "*We're reacting with 1985 technology, but we don't want to know [what happened] after the fact. We're too focused on reaction time. We need to focus on predicting by picking up on cues and changes in behavior.*"

Four companies aimed to increase and enhance social communication for their clients via video calls, picture/message exchange, and game-play. Connecting clients to their loved ones in this way prevents social isolation by creating shared experiences, even when family members are not able to be present. These connections, in addition to game-play, also have the potential to aid clients with memory training.

Two software companies focused on becoming an all-in-one platform, or "one-stop shop," for their customers. Both companies emphasized their desire to provide a product that offered a comprehensive solution for home

care needs by offering solutions to address the many aspects of and parties involved with the delivery of home care.

Two companies focused on education; one offered an online healthy behavior education tool (for caregivers, among other groups), while the other provided virtual caregiver training. Although these companies used different educational techniques, both aimed to empower caregivers by allowing them to see the experience of disability from another perspective. One interviewee emphasized this point by saying, *"It's really about transforming the way that people think, which in turn transforms people's actions, which transforms wellbeing. By increasing someone's self-efficacy and confidence, they can set a goal, accomplish it, and empower themselves. Having this transformation allows profound changes to happen under their control."*

Many, although not all, companies also had products with goals that centered on the health workforce, which are discussed in the section below titled "Health Workforce."

Unique Quality of Technologies

Most interviewees commented that their particular product was unique, or that there was "nothing quite like it" on the market, despite the fact that we categorized several products into the same taxonomy. Interviewees' explanations for why their products were unique, which are not mutually exclusive, included:

- Combining multiple technologies
    - Using new software developments with existing pieces of hardware
    - Offering a more comprehensive suites of services
- Enhancing capabilities and functionalities of existing or "traditional" products
    - Improved accuracy (e.g., sensor and GPS technologies)
    - Reduced burden on user (e.g., automated features, improved wireless connections, improved batteries)
- Designing software for specific audiences (e.g., aging, chronically ill/complex, and clients with dementia)
    - Simple interfaces and product set-up
    - Proactive technology (e.g., voice-first)

    - Person-centered designs (i.e., individualization or localization)
- Modifying existing physical structures
    - Better-designed living spaces (i.e., safer and more comfortable homes)
- Integrating with existing software (e.g., EHRs, HR systems)
- Providing a new educational perspective/immersive experience
    - Demonstrating presence learning; encouraging increased self-management, confidence, competence, and hope

Settings

The setting in which these products were used varied and were generally not limited to use in one particular setting. Ten products were completely or partially intended for in-home use or had customers who were in the home care market. This included technologies from the following taxonomy categories: robots, wearables, patient-employer engagement, staffing and recruitment, home-to-clinic communication, education, alarms and alert systems, facility/home health management, documentation, and remote monitoring.

Eight products were designed completely or partially for use in different types of senior care facilities, such as assisted living, nursing homes, and/or memory care facilities. These included technologies from the following taxonomy categories: robots, wearables, home-to-clinic communication, patient-employer engagement, education, assisted living, staffing and recruitment, and remote monitoring.

Five companies had products that could be applied to both in-home and facility settings. These included technologies from the categories: wearables, home-to-clinic communication, patient-employer engagement, education, and robots.

Not all companies interviewed were limited to the US. Two companies were based abroad, but only one of these has clientele in the US. Another 2 US-based companies had clients in other countries (e.g., New Zealand, Canada, Japan) and planned to expand into additional countries.

Company Financing

Venture Capital Funding

Several companies were funded through venture capital (VC) investments, among other sources, such as angel investors. Interviewees described several challenges to securing VC funding. One interviewee stated that there are only 2 VC firms that invest heavily in the long-term care technology space. Another interviewee described the additional challenge of firm-specific priorities; each VC firm has its own philosophy about which kinds of technologies to fund, making it difficult to appeal to multiple companies. Yet another interviewee stated that as of 2014, only 0.7 percent of overall VC funding was allocated toward products/services in the long-term care field.

It was also reported that more software, as opposed to hardware, products tend to be backed by VC money. According to interviewees, this is due to the fact that hardware is more difficult to develop and more expensive to fix. Hardware may also be subject to a prolonged regulatory approval process. As a result, hardware products require more capital and may be considered higher risk or may have a poorer short-term return.

Payment and Marketing Models

Across all companies, the types of customers, marketing, and payment models varied. Some companies sell their products to other businesses, known as a business-to-business (B2B) model. B2B models were more common when products/services were being used within a facility (e.g., assisted living). In these situations, the cost of the product/service were typically built into the residents' fee. Others reported selling directly to individual consumers, or a business-to-consumer (B2C) model. B2C models were more common when products/services were being used in the home. Some companies did, or were willing to, use both marketing models if they had different types of customers.

Regardless of whether or not they operated under B2B or B2C models, most of the companies sold their services on either a monthly or annual subscription basis. Few companies used an alternative cost/payment models (e.g., payment based on program completion).

Products/Services Aimed at the LTC Health Workforce

Benefits for the Direct Care Workforce

Many of the interviewed companies reported the value that their service/product had on the lives of the direct care LTC workforce, including home care and home health aides as well as certified nursing assistants (CNAs). Of the companies with products that were used directly by workers, several (3) specified that they had goals to empower workers. Examples of empowerment included allowing workers to have more control over their own schedule, providing them with tools to do their jobs more efficiently and effectively, and giving them a stronger voice in organizing the work. One of these companies also emphasized the importance of creating defined career ladders and ensuring that workers only need to work with clients with whom they are comfortable through an appropriate client-worker matching process. This company reported having high worker satisfaction scores and retention rates. Another of these three companies stressed that its business model would create more jobs.

Two of the companies that developed educational products aimed to deliver content through newly created and adapted tools, to increase their efficacy and relevance. Both products could be applied to the direct LTC workforce as well as friend/family informal caregivers.

Benefits for Family and Informal Caregivers

Companies with products designed for use by family or informal caregivers also aimed to improve the general workforce. One company hoped that their product would relieve some parts of the care burden, thus allowing family members more time to themselves and to remain as contributing members to society. Much of the focus on products and services that could be viewed as valuable to families were focused on using software to enhance virtual communications and ongoing social contacts when distance from family or living alone were considered risk factors to aging at home.

Benefits for Other Members of the Healthcare Team

Many companies (5) also described how their products affected other members of the healthcare team. These health professionals included

primary care providers, nurses, behavior specialists, and emergency services providers. Most of these products were designed to provide a comprehensive evaluation of a patient's health status, which in turn could inform health professionals of important changes in a client's condition or status that might require an urgent intervention. Four of the products were designed to allow health professionals to receive alerts and updates about patients' condition(s) through the technology's platform.

Workforce Efficiencies

In addition to these technologies' goals of supporting clients, their formal and informal caregivers, and health professionals, they also aimed to improve general workforce efficiencies. Two products tracked staff location where staff spent their time in a facility and/or what activities they performed) in an effort to learn where they could best be deployed within the facility to best address patients' needs. One of these two companies specified that doing so allowed workers the opportunity to engage in a certain level of self-management.

Five companies commented that their technology improved time efficiencies through different methods, such as tracking where staff spent their time and replacing certain in-person interventions with technology-based interventions (e.g., reminders, social activity, remote monitoring). They reported that their technology allowed for more visibility of clients' needs, which then allowed tasks to be delegated properly. In other words, the technology could provide a clearer picture of which clients need which services, and when. It allowed nurses to spend more time completing designated nursing tasks during their visits, giving the direct worker an opportunity to complete other tasks. Some technologies also allow certain tasks to be automated, which could ensure that caregivers maximize their time as well.

Two of these 5 companies commented specifically on how their technologies may or may not lead to a reduction in the frequency of home visits. Both said that they did not necessarily believe that their products would contribute to overall visit reduction, but that they would instead ensure that visits were more productive by illuminating which patients were most in need of what types of care.

Six of the interviewees commented that their products could improve workforce recruitment and/or retention. According to these companies, features such as enhanced documentation, data collection, and analysis tools provided several different ways to achieve this goal:

- Keep staff engaged by providing more information to them
- Allow for schedule flexibility
- Allow for more control over choice of clients
- Allow staff to work at the top of their skill level
- Identify low and higher performers to appropriately reward those who do their job well
- Ensure that the best candidates are hired into positions

Barriers to Technology Use

Some interviewees said that because their emerging technology is new to the market, their products are not always well understood (or understood at all) by potential clients. Thus, there is an initial challenge in first explaining what the technology does, in addition to then explaining the value of the technology.

For some companies, the cost of the product(s) were described as a barrier for technology uptake. A few companies described their products as offering higher-end services, indicating that their products cost more than what the average person could necessarily afford. Given that most companies only had limited 3rd party reimbursement structures, product costs remained as a barrier for those who could not afford the out-of-pocket costs.

Other companies discussed how the introduction of new technologies is often perceived as interrupting current workflows, which could also act as barriers to product uptake. For example, products that require additional documentation may not be appealing to healthcare providers who already spend a significant amount of time on documentation. Furthermore, once adopted, the capture of additional data means that there must be staff who know how to read and have enough time to interpret the data. Even then, additional training of existing staff must occur to ensure that these new insights are properly acted upon.

One interviewee discussed data privacy and data security, stating that there are existing concerns about voice-first technology. According to the interviewee, products with a shared service model would be providing information to those already receiving healthcare information (e.g., healthcare providers, family members, etc.). The forthcoming challenge would be how to distribute this information to each party appropriately. This interviewee commented that although voice-first technology is not quite as intrusive as video, there are concerns to be considered.

Another interviewee, whose product is designed to enhance documentation in long-term care facilities, described the importance of culture change, or a paradigm shift, in adopting new technologies: "*Those that don't have this culture [a shift in perspective that is necessary to deliver good care and answer patient needs] in place will struggle with their software unless they have guidance. [Our product] is not a solution – it's a tool to make the work easier and more scalable.*"

Lastly, as many of these companies continue to expand their suite of offered services and grow in size, several said that there are challenges in keeping up with the general pace of expansion. One interviewee said that it is difficult to anticipate what will "break" next: "*We expect the unexpected and take [challenges] as they come*."

Discussion

This study was conducted in an environment of increased concern about an aging population, in the US and worldwide, and a hope that emerging technology could help relieve the burden of current and projected demand for long-term care workers. Its intention is not to replicate previous studies and reports that have documented a plethora of developed or promising technologies from robots with hands-on abilities and/or artificial intelligence to smart homes equipped with sensors, safety devices, alert systems, health data collection devices, and social companion/therapeutic robots. Rather, our purpose was to focus on the workforce and the potential for various types of technology to affect the workforce. Specifically, we were interested in discovering if there were technologies that could potentially replace the human worker, which technologies might facilitate the hands-on workforce, and which technologies might address the known challenges of recruitment and retention of the LTC workforce.

Impact on the Workforce

Interviewees were consistent in responding that technology that will fully replace the direct care workforce is still a distant goal. Robots developed in Japan (Robear) assist with lifting patients to help to take physical strain off the worker, but generally are used side-by-side with the worker.[14] Socially Assistive Robots (SARs), such as robotic dogs, cats, and seals, have been found to increase social connectedness for isolated adults.[15] While robotic solutions that connect to home automation systems and family members continue to be developed and improved, they are not likely to mitigate the workforce shortage.[16]

Technology solutions that facilitate the workforce were more prominent in our research findings. We found technologies, such as remote monitoring devices/systems, that collected data to be forwarded to different members of the healthcare team. These data could inform home visit needs and identify which team members were needed in the home. Enhanced documentation tools allow for the capture of new data to improve staff's understanding of client behavior and manage day-to-day tasks. Wearable technologies could act as a 2-way communication tool for staff, alerting them to patient location for emergencies or predicting fall risks. Several types of technologies (e.g., robots, wearables, all-in-one platforms) assist with tasks such as medication and activity reminders when caregivers and family are away. New educational tools have been developed to increase knowledge on certain conditions, promote proper caregiving techniques, and teach sympathy/empathy to improve care delivery.

We also found technology that addressed workforce recruitment, retention, and staffing efficiency. For example, predictive analytics are used to identify candidates best suited for certain long-term care positions, which is beneficial to both initial recruitment as well as long-term retention. Other techniques to improve retention include more choice in shift scheduling, work location, and clientele. Staff efficiency was improved by real-time location tracking for quick assistance in emergent situations and analysis of those location patterns for enhanced long-term insights.

Barriers

Previous studies have documented some of the barriers to widespread adoption of an expanding number of new products and services. Those including consumer concern about privacy and the security of health data, usability, and cost.[11] Other challenges include potential differences in product specificity or acceptance among diverse racial and ethnic groups. The problem of lack of internet connectivity in many rural areas makes many of these products and services less useful and unreliable.

Partnerships in Developing Technology

The development, implementation, and evaluation of technology to support the aging and chronically ill, their families, and the long-term care workforce should be, but is often not, developed in partnerships between long-term care providers and researchers and the technology industry. Unfortunately, all too often, products are created without a user-centered design, which considers the needs and characteristics of the user. Adopting this type of approach requires interactions between system designers, psychologists, and human factors engineers, as well as active involvement of users during the design process.[11] There are examples of successful industry end-user and health system collaborations. For example, Oregon Health & Science University and Intel collaborated to develop and test devices to detect motor and cognitive changes in older adults in community settings.[17] In addition, one of our study participants, Alma's House in Oslo, Norway, is an engineering, healthcare team, and provider collaboration that is set up to test and analyze the effectiveness of products and services and receive the organization's recommendation before approving their release into the market.

Cost to Consumers, Lack of Third-Party Reimbursement

Most of the products and services we researched billed the cost of their services direct-to-consumer or direct-to-facility. Technologies with a hardware, in addition to a software, component often included an installation set-up charge with an accompanying monthly subscription thereafter. At times, some initial training on how to use the product/service was also included. There was little to no reimbursement by third-party payers (e.g., Medicare, Medicaid, or private insurers), and private pay only services will be

limited in adoptability if they are only available to those who can afford to pay. Several companies were trying to negotiate third-party payment or were at least thinking about third-party reimbursement in the future, but little progress has been made. One reason for this may be that third-party insurers are waiting to see more peer-reviewed evidence of effectiveness. Several companies had partnered with researchers to collect and analyze data on patient outcomes and/or facility efficiencies to determine the impact of these technologies. Although a few companies did have some known outcomes, several had not yet published their outcomes in peer-reviewed journals or reports, or were not sure if they would publish their outcomes. Several companies had testimonials on their websites.

Limitations

Environmental scans are potentially limited by missing critical information in the scan and/or by making incorrect interpretations of the gathered information. We addressed this by repeating the scan process several times during the course of this project. In addition, we used multiple sets of search terms in each scan. Another limitation is that we interviewed roughly one product/service from each category of the taxonomy created; the goals, experiences, challenges, and outcomes reported by each company may not be representative of other technologies that fit into that same category. Finally, we conducted most of the interviews by phone and did not obtain real-world observations or collect data on whether the products/services always work as described. However, the interviewees were very open about the challenges that they encountered with their products and services, and many offered data collected by their company or a partner organization related to outcomes and effectiveness.

Conclusion

Long-term care technology is a growing industry with capital investments made in many new products and services developed each year. However, there is little research on which technologies will have the greatest potential impact on the workforce that is providing direct care. Reimbursement from federal and private payers is minimal to date, yet demand for government payment may grow as use of these technologies grows in the long-term care sector. Payment issues aside, there is opportunity for emerging LTC technologies to enhance quality of life for patients, assist friend/family caregivers, and improve workforce efficiencies.

Acronyms Used in this Report

ADL: Activities of Daily Living

B2B: Business-to-Business

B2C: Business-to-Consumer

CNA: Certified Nursing Assistant

IADL: Instrumental Activities of Daily Living

LTC: Long-Term Care

SAR: Socially Assistive Robot

VC: Venture Capital

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Appendix. Interviewee Company Summaries

Alma's House

Located in Oslo, Norway, Alma's House is a model for technology-fortified living spaces that allows the elderly, particularly those with dementia, to live independently longer. A main design tenet is that the living quarters resemble an apartment rather than a medical institution. Beyond housing the smart home display, Alma's House is also a research center that continuously investigates new technologies that would improve the quality of life of its residents.

Many of the dementia-friendly elements of Alma's House are simple; lighting is bright and is focused on heavily trafficked areas, colors contrast to promote visibility, and notes on doors serve as reminders for its residents. However, more complex technology, such as infrared sensors, medication dispensers, and embedded GPS technology can also be incorporated. These features and technologies can be purchased for the home, many of which are paid for by Norway's government, while others must be paid for out-of-pocket.

Arena

Arena is a predictive analytics company with several US offices that aims to improve healthcare organizations' patient outcomes. It identifies job applicants who are most likely to achieve the outcomes that an organization seeks, and routes those candidates into best-fit roles, locations, and departments where they will aim to achieve those outcomes. Arena uses machine learning to yield measurable outcomes with the goal of improving staff retention rates and other operating metrics. Arena is used in both acute care and long-term care settings.

For data collection, the software is integrated into an organization's HR system. In addition to using data from applications, Arena collects data through a separate portal that asks applicants to solve puzzles and then observes their behavior. Arena also incorporates third-party data from sources such as the Bureau of Labor Statistics and Glassdoor. Information from all three data sources are run through an algorithm, which then delivers a set of predictions to recruiting / hiring managers.

Canary Health

Canary Health is a US-based digital therapeutics company that provides individual support services by mimicking traditional in-person programs in an online setting. Creating behavior change via guided lessons, action plans, and peer discussion are the basis of Canary's three products: Virtual Lifestyle Management® addresses diabetes prevention; Better Choices, Better Health improves the self-management of any chronic condition; and Building Better Caregivers supports family and friend caregivers.

The programs are designed to teach users self-management. Virtual Lifestyle is based on a US Centers for Disease Control and Prevention recognized diabetes prevention curriculum and is comprised of 16 weekly sessions followed by eight monthly self-guided lessons. Better Choices, Better Health is a 6-week, peer-to-peer program focused on establishing self-efficacy, increasing competence, and managing their lives with chronic condition(s). After 6 weeks, participants can join an alumni community that acts as continued support. The structure and much of the content of Building Better Caregivers is similar to Better Choices, Better Health, but it caters to specific caregiver needs. All programs are facilitated by trained health coaches and often address social and emotional needs, in addition to the medical, components of dealing with chronic conditions.

CarePredict

CarePredict is a senior care management company with several locations in the US. CarePredict offers an array of products that combine wearable technology, indoor location tracking, machine learning, and predictive analytics. These products can be used by individuals aging at home as well as multi-community senior living facilities, such as assisted living, independent living, and memory care.

The wrist-worn wearable sensors collect various data points on its wearer, including individuals' activities of daily living (ADLs) and location. The wearable's other functions include: acting as a 2-way communication tool (walkie-talkie-like function), alerting caregivers to emergencies (once the assistance button has been pressed), and serving as an electronic mechanism to open locked doors. When used in senior living facilities, the

wearable technology can also be worn by staff, which allows for insights into usage and allocation of staff time as well as staffing patterns.

ClearCare

ClearCare, based in the US, is an online platform for non-medical home care that aims to expand agencies, manage caregivers, improve care delivery, and optimize operations. The software is designed to assist each member involved with care delivery, including healthcare providers, caregivers, care recipients, schedulers, billers, marketers, and recruiters.

ClearCare offers customer relationship management, marketing, and hospital/readmission tracking tools, as well as provides connections between organizations within their network. Caregivers submit applications online, including an integrated background check, through a managed tracking system. Once hired, they are enrolled in a caregiver safety program. Care is then delivered using 3 point-of-care modalities: phone landlines, a caregiver mobile app, and traditional online capabilities with the goals of facilitating shift scheduling, electronic visit verification, mobile access to client information, and information sharing between clients and family. ClearCare uses electronic timecards and invoices, as well as a customizable home care reporting system and compliance tools.

Intuition Robotics (ElliQ)

Headquartered in Israel with offices in the US, Intuition Robotics' product ElliQ is a robotic device built to alleviate social isolation for older adults and promote healthier aging. ElliQ's body, which swivels around and encompasses LEDs, is paired with a removable tablet. ElliQ and the tablet can be physically connected by the base, which includes a speaker, microphone, and a tablet charger.

ElliQ supports video calls and messaging, photo sharing, calendaring and reminders, news and weather, cognitive stimulation/games, question and answer, and curated music and videos. Through the use of artificial intelligence, ElliQ is designed to become more helpful as it learns what is liked and needed. Messages are sent and received through an accompanying app. The app is able to tell friends/family/caregivers when the user was last seen in the room and allows them to suggest activities to the ElliQ user.

Because the tablet is removable, video calls to be taken in a room different from the one where ElliQ sits.

Embodied Labs

Embodied Labs is a US based company with several locations that provides virtual reality (VR) training for healthcare workers, serving long-term care/senior services, hospital systems, and higher education for health professionals. The training tool is designed for both professional and family caregivers. The VR experience simulates key problems and situations as well as demonstrates client, patient, parent, community member, and resident perspectives.

The VR technology relies on live film as opposed to computer-generated imagery in order to achieve an immersive experience. The principles of embodied and presence learning form the underlying philosophies that drive Embodied's data on efficacy and simulation. Each module lasts 10-15 minutes; the immersion session takes 7-10 minutes, and an accompanying session assessment 3-5 minutes. Currently, there are several available modules that address end-of-life conversations, Alzheimer's disease, and macular degeneration, with more in development.

GrandCare®

Based in the US, GrandCare® is a technology company that offers a suite of features linking seniors to their family members, caregivers, and health professionals. GrandCare®'s goal is to improve client health outcomes, beginning with their large touchscreen interface that provides activity and health monitoring, medication prompts, and communication. Clients are not required to have any computer skills in order to use GrandCare®.

In addition, GrandCare® integrates with devices such as motion sensors, contact sensors, action buttons, blood pressure devices, and glucometers, among others, to track specific health conditions. GrandCare® facilitates socialization through video calling, photo and video sharing, and a closed messaging system. The care portal allows caregivers and health professionals to view clinical and non-clinical notifications, control touchscreen content, and edit reminder settings to encourage clients to stick to designated activity patterns and wellness readings.

Honor

Based in the US, Honor aims to create a better and more reliable home care experience for care recipients, caregivers, families, and agencies through machine learning and specific operational techniques. In an effort to achieve this, Honor strives to enable a more personalized relationship between CarePros (professional caregivers) and clients receiving care. Honor partners with local, non-medical home care agencies through the Honor Care Network; its services are currently available in many cities throughout California, New Mexico, and Texas.

Honor's belief that the direct requests humans articulate are not directly telling of how humans actually behave forms a core part of their home care model. Data across the CarePro workforce and care delivery, including measures such as which jobs CarePros accept and which CarePros are blocked by clients, are analyzed to determine matches between clients and CarePros. In addition to aiming to improve client-caregiver matches, other goals of Honor include: enhancing shift scheduling, providing performance management roadmaps, tracking CarePro reliability to facilitate CarePro retention and satisfaction, and promoting data-sharing between clients and their family members.

La Valeriane®

La Valeriane Health Solutions, a subsidiary of La Valeriane®, is a French company that works in three main fields and markets: preventive care, care management, and disease management. Its 2 products, Balance Stress Health and EMA-Care, are intended to reduce stress in personal and work life and enhance coordinated care for the elderly, respectively.

Balance Stress Health assesses individuals' stress levels through a diagnostic tool that takes about 45 minutes to complete. Consumers then develop a health maintenance plan based on the diagnosis. This product targets companies that wish to improve their employee satisfaction rates through an improved understanding of their corporate culture and psychosocial risk factors. EMA-Care is a tool designed to evaluate the independence and autonomy of elders through 17 daily acts, including mood, and then builds an individual care and support plan based on that assessment. Their software assesses care recipients on three dimensions – cognitive ability, cognitive

ability + physical ability, and physical ability – rather than ADL/IADL measurements. This app is used in home care and several types of senior care facilities.

LifePod™

LifePod™ Solutions, Inc., located in the US, is a proactive voice system that allows professional and family caregivers to play a more active role in in the lives of the ones that they care for when not physically with them. A combination of software (integrated with Alexa via standard Alexa Skill APIs) and hardware (Alexa-Inside speakers with special firmware), LifePod™ has the ability to prompt users proactively and features a calendaring system controlled by the LifePod™ Caregiver Portal (aka Dialog Management System), which can stand alone or be integrated with another calendaring system. LifePod™ plans to integrate additional features going forward, such as remote monitoring capabilities and sensors.

Caregivers personalize LifePod™ to the particular user by controlling proactive reminders, dialogues, and check-ins. Additionally, because LifePod™ allows for two-way communication, caregivers can adjust reminders and other controls based on the feedback they receive from the LifePod™ user. Caregivers are also sent alerts via text messages to inform them of important changes or emergencies that may be happening to the user. LifePod™ is designed to be complementary to in-person services and is used in home care, home healthcare, and senior living care.

UnaliWear™

Based in the US, UnaliWear™'s Kanega watch is a smartwatch for seniors. Designed with style in mind, the watch's technology aims to keep seniors independent, active, and safe. An all-in-one, voice-controlled device, the Kanega watch does not require a connection to a home-based system nor a smartphone, meaning it is useable away from home as well as in the home. The technology is meant to be adjunct to in-person care.

The Kanega watch combines cellular, Wi-Fi, GPS, and BLE capabilities with an accelerometer for automatic fall detection, continuous speech for medical alerts, and artificial intelligence that learns the wearer's daily lifestyle routines. The battery system does not require users to take the watch off at

night. Users can program the watch to prompt them for certain activities, such as medication reminders, with texts, vibrations, or voice. Emergency contacts and emergency services can be called and dispatched, either on an on-call or emergency detection basis. Kanega watches are currently being sold to individuals and are used in the home and in the senior living setting.

VisibleHand

VisibleHand has two products, VisibleCare and Foresight, and is based in the US. VisibleHand's goals are to improve patient safety and reduce risk. While VisibleCare focuses on acute care, Foresight is an EHR-integrated behavior documentation tool used to inform behavior care decisions in skilled nursing facilities.

Foresight strives to improve staff understanding of residents' behavioral needs and how those needs are best addressed in long-term care facilities. Information that might not be captured in an EHR is documented and systems are updated in real time to connect staff, such as front-line workers, nurses, clinicians, administrators, and MDS coordinators, with the comprehensive behavioral information on each resident. Staff then use this information to improve antipsychotic usage, reduce (re)hospitalizations, increase reimbursements, and more. Skilled nursing facilities record this information and make it accessible to all staff in hopes of intervening in a potentially dangerous situation before it escalates. Foresight can also produce reports of behavioral trajectories and help to ensure regulation compliance.