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Expanding Rural Opioid Addictions Treatment: An Inter-institutional, Inter-professional Telehealth Case Study Simulation

Authors
Maria Gilson deValpine, RN PhD, James Madison University School of Nursing
Kristin Hanula, MSW, LCSW, University of Virginia Health System Department of Social Work
David Trinkle, MD, Virginia Tech Carilion School of Medicine and Research Institute
Rebecca Poston, PhD, RN, CPNP-PC, Old Dominion University School of Nursing
John Owen, EdD, MSc., University of Virginia Center for Academic Strategic Partnerships for Inter-professional
Valentina Brashers, MD, University of Virginia Center for Academic Strategic Partnerships for Inter-professional
Erica Lewis, RN PhD, James Madison University School of Nursing

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Abstract

Purpose: To determine if inter-institutional collaboration, using telehealth technology, inter-professional education techniques, and case study methodology is a feasible way to teach health professions students how to appropriately address opioid addictions, especially in rural populations with limited health care access.

Study subjects: Ten health professions students from four Virginia universities participated. Professions represented included medicine, nursing, physical therapy, social work, nutrition, and psychology at the graduate and undergraduate levels.

Methods: Inter-professional faculty from four Virginia universities developed an opioid addiction simulation case study using a standardized patient. Students from different regions engaged in a facilitated patient interview and care planning via secure virtual meeting platform. Faculty observation and feedback, student feedback, and inter-professional education assessments were used to assess this pilot study.

Findings: Inter-institutional faculty collaboration and telehealth technology was successfully employed to convene multiple health professions students from different sites; simulation case study methodology using a standardized patient was effective and compelling; students effectively utilized interprofessional competencies and skills to develop a comprehensive and holistic care plan for opioid addiction treatment.

Conclusions: Telehealth technology, inter-professional education, and simulation case study methodology can be successfully used to teach health professions students how to collaborate to address the opioid crisis, especially in resource-limited rural areas.

Implications: Many resources are necessary to successfully treat opioid addictions. By using telehealth technology combined with inter-professional concepts and skills, resources can be shared between institutions and professions to successfully treat patients with opioid addictions in resource-limited areas.

Introduction

The opioid crisis in the United States is a national, state, urban, and rural public health emergency. It is particularly hard felt in rural, economically underdeveloped and medically underserved areas such as Appalachia and former coal mining regions in the U.S. For example, in 2013, Virginia reported more fatal overdoses than traffic fatalities, with the highest numbers in seven rural counties (Commonwealth of Virginia). An estimated 1,079 Virginians died from opioid overdoses in 2016. In addition, Virginia Medicaid (public assistance) members are prescribed opioids at twice the rate of non-members and are at three-to-six times the risk of prescription opioid overdose.

In January 2017 the Governor of Virginia declared the opioid crisis a public health emergency and enlisted the state Task Force on Prescription Drug and Heroin Abuse to develop measures to address the crisis (Levine, 2017). Subsequently, in April 2017, Virginia Medicaid expanded community-based addiction and recovery services, scope of practice and training for medically assisted treatment, integrated physical and behavioral health, and reimbursement for telehealth, among other interventions (Governor's Task Force on Prescription Drug and Heroin Abuse, 2015; Virginia Department of Health Professions, 2016; Virginia DMAS, nd). These benefits are especially useful to rural areas struggling with high rates of opioid addiction, limited resources, and dwindling numbers of health care providers. The focus on telehealth and inter-professional practice are critical to effectively implementing community-based and integrated physical/behavioral health care services.

Addressing the opioid crisis requires health professions educators to respond through curriculum development. Acknowledging that inter-professional education is key to inter-professional practice (Brandt, Lutfiyya, Kind, & Chioreso (2014), health professions education faculty at four Virginia universities successfully developed and tested an inter-professional telehealth education case study for opioid addiction management and treatment. Medical, undergraduate nursing, nutrition, social work, physical therapy, graduate psychology, clinical nurse specialist, nurse practitioner, and doctor of nursing practice students were convened via telehealth technology. Using inter-professional competencies, skills, and practice behaviors (Muzyk, Tew, Thomas-Fannin, Dayal, Maeda, Schramm-Saptya, Andolsek & Holmer, 2017), the students collaborated to interview and subsequently develop a comprehensive plan of care for a standardized patient suffering from prescription and subsequent illicit opioid addiction.
Interprofessional Education

Traditional educational models for health care professionals often include 'siloed' approaches with profession specific coursework housed within school specific curricula, thus limiting opportunity for interprofessional engagement and learning. The Lancet Commission on Education of Health Professionals for the 21st Century (Frenk et al, 2010) called for new instructional and institutional approaches to kickstart innovation in health professions education in an effort to address "tribalism of the professions" which results from professions training and practicing in isolation from and in competition with each other (p.1923).The need for innovation in healthcare education dictates that as educators we "shed our protective professional skin" and transcend the natural boundaries to embrace a collaborative approach that challenges the traditional 'silos' of profession specific education (Poston, 2014). Specific focus on the interdependence between health in the global sense and health professions education as outlined by the Lancet Commission requires significant changes in how health professions experience education and training to include shifts from single institution to interinstitutional collaboration and alliances that capitalize on shared resources, expertise and experience (Frenk et al, 2010).

Forty-five years after the Educating for the Health Team (Institute of Medicine, 1972) report, progress has been made towards developing educational experiences and crafting curricula that address interprofessional practice competencies outlined in the revised 2016 Interprofessional Education Collaborative report (IPEC, 2016). Specific IPE curricular requirements now are visible in healthcare education accreditation documents (e.g. Liaison Committee on Medical Education (2017); Commission on Collegiate Nursing Education (2011)). Yet, there is little standardization in how this is achieved or measured (Zorek & Raehl, 2012).

Despite national focus from leading health professions organizations and accrediting bodies for health care professions education, integration of IPE activities, courses, seminars, and experiences into established content heavy curricula for health professions students is challenging and there are known inherent structural barriers (Gilbert, 2005; Cahn, 2014). According to Lewis, Anson & Greenfield (2014), institution specific barriers include: limited financial resources and administrative support, lack of faculty development initiatives, scheduling of IPE within current programs, health professional degree calendars, different degree timetables, rigid/condensed curriculum, extra-curricular versus required course/unit, and differences in assessment requirements. Additionally, educators are often limited in the diversity of available health professions students to engage in curricular activities focused on developing competencies related to interprofessional practice. Strategies to overcome institutional barriers and limitations, such as those offered here, are necessary to move IPE forward across all health professions education programs regardless of size and diversity of health professions student mix.

Methods

Health professions faculty from the University of Virginia (UVA), Old Dominion University (ODU), Virginia Tech Carilion School of Medicine (VTCSOM), and James Madison University (JMU) collaborated over one school year to develop and pilot an inter-professional opioid addiction simulation case study for health professions students using telehealth technology. Each University brought strengths to the collaboration. JMU is a large public institution with more than 20,000 students. Its College of Health and Behavioral Sciences oversees seven health related disciplines. VTCSOM enrolls more than 4,000 students annually and has a curriculum uniquely focused on inter-professional education. Both JMU and VTCSOM are located in the Shenandoah Valley, a rural and largely underserved region situated in the western part of the state. ODU is located in the southeastern area of the state and is one of the largest providers of distance learning degree programs in the country. Graduate nursing programs at ODU are especially focused on developing a network of advanced practice nursing providers in rural and medically underserved areas via distance learning and telehealth modalities. The UVA Health System is a large teaching hospital with a well-developed telemedicine program and a service area that includes the rural, western half of Virginia as well as eastern West Virginia.

All four universities have large-scale inter-professional education programs for the various health professions. 4-VA, a consortium which awards grants for collaboration, research, and collaborative use of technological resources in the STEM fields, provided funding for this pilot program. Human Subjects Review and oversight was provided by James Madison University. Each university's institutional review board reviewed and concurred with the James Madison University Institutional Review Board approval. The opioid addiction case study was developed by collaborating faculty in consultation with pain management, telehealth, and inter-professional education experts (Figure 1). Faculty met for planning purposes in person at each university and virtually, using the same technology used to implement the case study with students (secure virtual meeting platform).

Case Summary

<u>Personal background:</u>

- Mr. Bob Johnson is a 50-year-old, manager at a large car dealership.
- Only medical treatment being hypertension.
- The family upper middle class and live in a multilevel Victorian home.

<u>Initial events</u>

- Nine months ago flipped his ATV
- Found to have an incomplete spinal cord injury (SCI) of his thoracic vertebrae (T-11).
- He was placed in an ICU and treated for pain with OxyContin.
- Underwent surgical decompression and stabilization of the T-11.
- Treatment for pain continued along with rehab.
- Eventually moved to a regular hospital bed and then had three weeks in a rehabilitation unit before being discharged home.
- Treated for hypertension and diabetes while in rehab.

<u>Complications:</u>

- Started on physical therapy and rehabilitation soon after surgery, but he had difficulty with this.
- He is home alone most days.
- MD switched him to Roxicodone 30 mg every 4 to 6 hours as needed and then gradually reduced the dose over a period of several weeks.
- He continued to experience pain along with nausea and craving.
- When he complains of nausea and craving the MD begins him on buprenorphine/naloxone combination. (Suboxone)

Current Crisis:

- At the urging of his family eight weeks ago, Bob tried to return to work
- Found it hard to keep up, felt the pain worsened and did not seem to have the energy, motivation or concentration he use to have
- The family had anger that Bob was not “trying more”.
- Found an old prescription of the OxyContin and began to use it in place of Suboxone.
- Decided to buy opioid medication off the street about two weeks ago, some of which were in hindsight likely laced with fentanyl and heroin.
- His wife confronted him and got him into a medical inpatient detox unit- discharged after 4 days
- Within 2 days of discharge he started using again
- Yesterday he presented to the ED with a heroin overdose that required Naloxone
- He was discharged from the ED and given an appointment the next day in a care center.
- The OPHI team is assembled to determine the best short and long term treatments to further stabilize Bob medically, provide detox, counseling, and other services to prevent opioid relapse and return Bob to healthy functioning. Family support will be needed.

Figure 1. The Student Case Study

Health professions students were recruited from each university (Table 1) to participate in the opioid addiction simulation case study. Prior to participating in the case, students received a professional role description and a brief overview of the case study. Students met in a telehealth facility at their home university with project faculty. After the faculty reviewed the consent process, case study objectives and inter-professional competencies with students at each site, the students convened across all four universities using a secure live virtual meeting platform, and established the means by which they would interview the patient and subsequently develop a comprehensive care plan. The standardized patient was introduced to the students who, in two brief sessions, proceeded with their established plan. The standardized patient was located in a separate room at one site. A faculty “case manager” accompanied the standardized patient, facilitating the interview process and answering complex clinical questions via secure virtual meeting platform.

	Medicine	Nursing	Nutrition	Social Work	Psychology	Physical Therapy
JMU		U	D	U	D	
ODU		D				D
UVA	D	D				
VTCSOM	D					

Table 1. Health Professions Students by University (D = Doctoral, G = Graduate, U = Undergraduate)

Students interacted with the standardized patient and each other in the secure live virtual meeting platform on large video screens, with voice activation shifting from smaller to larger perspectives. Support from technical staff was necessary and was provided by 4-VA staff at each university. Students and the standardized patient signed informed consent to participate in the project, and completed a survey with four research instruments (Inter-professional Attitudes Scale (IPAS) (Norris, Lassche, Joan, Eaton, Guo, Pett & Blumenthal, 2015), Team STEPPS Team Assessment Questionnaire & Attitudes Questionnaire, Team Skills Scale (https://www.ahrq.gov/teamstepps/longtermcare/sitetools/tmassess.html; https://www.ahrq.gov/teamstepps/instructor/reference/teamattitude.html). The goal of the survey was to determine if any of the four instruments were suitable to measure lessons learned by students after this case study. Faculty who did not participate in the case study also assessed students using the Inter-professional Collaborator Assessment Rubric to determine if this rubric was useful for evaluating students during this case study (Grymonpre, van Ineveld, Nelson, Jensen, De Jaeger, Sullivan, Weinberg, Swinamer & Booth, 2010). Survey results are published elsewhere.

Results

Faculty Observations

Faculty observed that one student took the initiative to be the team leader. Telehealth technology facilitated this student’s effort to ensure that the other students were asked for input. Medicine and graduate nursing students had questions about pharmacologic issues, but most of the students’ interview and plan were more focused on psychosocial issues. The assessment of the patient was expanded and enhanced by questions posed by social work, physical therapy, undergraduate nursing, and nutrition students who asked about financial, employment, and family dynamic concerns. The patient was given time to respond, and non-judgmental and compassionate communication was used throughout. The interview segment of the simulation was followed by a lively student discussion about options for supporting the patient's next steps for rehabilitation, with input from all students incorporated. The team used respectful communication, shared problem solving, and shared decision making skills as they worked through the many challenges faced by this individual. The care plan they developed together included clear and feasible steps for the patient to obtain additional support for his physical, nutritional, psychological, financial, social, and family needs. The students then returned to the patient to communicate their plan. The patient occasionally resisted some of the recommendations, with students handling these concerns with supportive options. In the end, the patient expressed his willingness to make important positive steps. A specific plan for follow-up actions was communicated, and ongoing support and communication were offered.

Student Feedback

Feedback on the pilot study was sought from students formally during debriefing after completion of the case study and during informal discussions with faculty at each site. Students felt they needed more time to interview the patient. A number of issues contributed to the length of time needed, and if resolved, could increase student comfort and effectiveness with inter-professional interviewing and care planning. There were also several suggestions for how the technology might be improved to better support team discussions. Overall however, students provided very positive feedback including one exuberant medical student:

> This was my first time ever speaking with students from many specialties that we don't train at UVA. I got a lot out of it . . . My brain was working hard and I was super engaged the whole time. This is a fun experience that will stick with me for sure!

Students also noted the assessment tools employed could be improved. They reported survey fatigue and wished that the survey could be shorter. They identified the IPAS as being able to represent their experience (Norris et al. 2015). Students also felt that the TSS could be useful if we gave clearer instructions that they were assessing the current team instead of other work teams in their responses (Grymonpre, et. al. 2010). They believed that the TSS would be useful only as a post survey (not pre-post). They also reported that the variety in the way the Likert Scale was listed among the surveys was confusing. The IPAS and/or TSS as pre/post test would improve data collection and the rubric for observing teamwork (ICAR) was less appropriate for this exercise than would be an observation tool such as the Performance Assessment for Communication and Teamwork Tool Set (PACT) (Chiu, Brock, Abu-Rish, Vorvick, Wilson, Hammer, Schaad, Blondon & Zierler, nd).

Faculty Feedback

Feedback was sought from faculty during a formal group debriefing session two weeks after the event. Much of the student feedback was observed and reiterated by faculty. Faculty suggested providing a more formal plan with supporting documents would be helpful. Students could use their time more efficiently with clear objectives and time limits, ground rules for communication, assigned team leaders, and facilitation by faculty. Faculty noted that a great deal of time was taken up by students requesting further clinical information during the session. Simplifying the case study so that little additional information is required would ensure that all student communications are represented, and the session is not monopolized by the search for clinical data. Faculty also felt that differences in the telehealth display from site to site made communication more difficult.

Regarding the surveys, faculty all agreed that the ICAR rubric failed to capture this particular experience well (Curran et. al., 2011). Faculty concurred with the student narrative feedback that the IPAS and TSS questions best represented the student learning outcomes for this diverse group of students for this simulation (Norris et al. 2015, Grymonpre, et. al. 2010)). Although we did not test these instruments with other simulation experiences, faculty perception based on this experience was that it could be used as a measure for other student simulations, although it was noted that some of the questions would apply better to some simulations and less well to others. Faculty assessed that the TAQ applied less well to assessing this simulation (AHRQ, 2017). In particular, the sections on team structure and leadership seemed not to relate to the simulation experience. The Team Assessment Questionnaire also didn’t seem to fit, in particular the questions about team formation seemed to require more time for team formation, function, team leadership, team identity, and performance subscales required more time together as a team than a simulation experience allowed (AHRQ, 2014). The Team Assessment Questionnaire subscales about team-skills and team climate did however seem to apply to this experience from the faculty perspective.

Faculty were overwhelmingly positive about the experience. They were pleased with the student engagement and interaction during the simulation activity. Faculty were energized by the idea of collaborating outside of their University. During the material development phase, faculty found the balance between virtual and in-person meetings to be useful, combining the efficient and flexible time (virtual) with the more effective and team building time (in-person) the team flourished and accomplished a great deal despite traditional barriers of institutional culture, geographic location and curricular/scheduling challenges.

Faculty discussed limitations of the experience. Faculty data validated all of the student complaints about the virtual meeting platform utilized for the telehealth encounter yet faculty also acknowledged the limitations of needing, for ethical purposes, to use the online meeting platform that allowed greater protection of confidentiality of recordings. Faculty discussed several technology options that may provide the desired experience but that were less secure. Other challenges included, designing a case for such a diverse student mix, logistical coordination, and institutional barriers to collaboration. Students varied in their levels of experience, education, previous SP experience, and previous telehealth experience; which was difficult to plan for. Logistics were complicated, and this would only be more difficult if the experience was scaled to include more groups. Merely finding a date and time to meet for the simulation was difficult given that the students had class at all different times of the day. The team discussed scaling the activity into a class, perhaps a term (May term, January term) class, that would allow for greater depth of experience and perhaps also greater breadth. Ultimately the team believes the activity was a success in part because each school had a dedicated, funded, faculty champion; and the mix of individuals was strong such that faculty enjoyed the experience.

Discussion

Case Study Development

The case was well utilized with this inter-professional group of students. The main problem identified was lack of time, and both faculty and students identified a number of tactics to improve efficiency. Chief among these was better coordination of roles, documents, communications, and objectives in advance of the event. In addition, faculty facilitation was key, and methods for intervention should also be agreed upon in advance. Important was the finding that this complicated case study naturally evoked student questions regarding testing, findings, and interim outcomes. Simplifying the case study and clarifying student roles will likely enhance the flow of the exercise and improve time management.

Based on the student evaluation of the case we discovered some improvements that needed to be made to the case and supporting materials. For example, we had observed that the student physician took the lead in organizing the case discussion. During debriefing, this student noted that the physician role description included the text that “as a physician I am trained to lead the team” and thus they felt that taking that leadership was part of their role. Students identified that this became a barrier to team interaction, as others may have wanted to take the lead given the chance to discuss and decide that early on. This was an important lesson for the faculty team, that each word used in the case materials can change the experience for the group. It also highlighted the importance of pilots, such as this, which include evaluation of the materials for gaining student perspective and make quality improvements. Additional changes were also needed to the case materials. For example, although students were sent the role descriptions for all involved professions, we failed to instruct them to review all roles resulting in students reviewing only their own. After this simulation experience ended, they stated that it would have been beneficial to have reviewed all roles and wished instructions to do so had been explicit in the preparation leading up to the simulation. Students were provided with a list of the events taking place during the simulation, however, they desired a more exact and detailed timeline and greater guidance on the timing for specific simulation sections, indicating this would lessen stress and improve their focus. Specifically, the timeline showed when students would interact with the patient. Yet, it wasn’t explicit that students were to come back the second time with more assessment questions. Therefore, the team moved too soon into creating the care plan and needed to be redirected by the case coordinator. In addition, students also felt that additional readings were needed to provide an interprofessional framework and readings specific to interprofessional behaviors. These findings demonstrate the need for clear/explicit instructions during simulations and again highlight the importance of gaining student perspective during case development.

Each of the professions contributed during the case. However, the individual in the nursing role contributed less often. This was discussed during the simulation debriefing. The student, as a generalist practitioner, felt that there were so many specialists present that there was less in the case for a health professions students with a generalist perspective. Moreover, the role of the care coordinator overlapped with traditional nursing responsibilities and may have led to less contributions for that student. The student group struggled with the idea that perhaps less professionals would have been better, at the same time they valued the contributions of each professional present. The simulation initially planned for two of the participants (dietician and psychologist) to be available via phone consultation but ultimately all students were in-person, which may have caused this problem. The diversity in student preparation was noted to be initially intimidating to the undergraduate students working with graduate and doctoral colleagues. Although the students noted that getting to know each other throughout the experience helped them to feel comfortable despite initial discomfort. Moreover, students were astute to the potential benefit of experiencing this during training since they may encounter the same discomfort in their future work.

Telehealth

Overall, telehealth technologies were well utilized to bring mental health and other professional resources together in this pilot study and the use of inter-professional skills and competencies can be employed to "smooth" any overlap, expand treatment resources, and ensure comprehensive care for opioid addicted patients. The students and the standardized patient all validated that they felt the lack of physical presence. Students noted practical ways of overcoming technology barriers such as pausing more often virtually than in-person to allow others to talk and re-stating their name and professional role prior to speaking. They suggested "hand raising" technology to solve that problem. They did believe that having a care coordinator present with the patient was important to maintaining flow during the case study.

In this pilot work students did not have a chance to connect in either asynchronous or synchronous environments prior to the simulation experience via telehealth. In future work it may be helpful to require team member to post short videos of introduction to a virtual platform to allow the team to 'get to know' each other prior to the simulation experience which may be helpful and leverage some of the potential of technology in healthcare. An alternative 'low-tech' approach of an asynchronous discussion forum prior to the simulation experience could also achieve the goal of introducing team members to each other. Real-life interprofessional team collaboration across telehealth may not always allow for team members to meet each other prior to their 'on screen' introduction, yet educational environments that foster a safe space for learning and practice should allow for such introductions aid the team through the 'forming' stage of team development (Tuckman, 1965).

To aid interprofessional student teams in their progression towards high function and collaboration, it may be helpful to provide students with reading materials to review prior to the simulation experience that outline individual health professions team member's roles/responsibilities/educational background/training. In this pilot work summary sheets for each health profession involved were supplied as reading materials to review prior to the simulation experience, but explicit instructions were not given for all team members to review all health professions summary sheets. Enhanced knowledge of one's team members' training/background/roles/responsibilities can impact the level of common/shared knowledge that the team begins the exercise with and therefore impact team cohesion and potentially team function.

Building on the work necessary to move the interprofessional team towards optimal performance, we suggest that the start of the interprofessional simulation experience via telehealth includes focused time for team building. Simple and brief ice-breaker activities that expose the depth and layers of each person's professional roles/responsibilities/training and potential contribution to the case could be helpful in building trust across team members. Additionally, it may be helpful to include a 'warm up' exercise/case that allows the team to practice transitions between providers throughout the interview with the standardized patient. The technical skills of interprofessional communication in a virtual telehealth encounter require nuanced changes in how team members navigate transitions in leadership. Attention to this specific skill development is necessary to aid in the fluidity of telehealth encounters, especially those that involve an interprofessional team collaborating across geographical and institutional boundaries. Addressing the human factors aspect of telehealth interactions is necessary and requires a focused agenda within the preliminary time prior to the standardized patient encounter (Demiris et al., 2010).

While we did not specifically address the presence of faculty members within each telepresence room in the overall evaluation of the experience, we surmise that faculty presence may have some impact on team function and team performance in the virtual space. Previous research from nursing on faculty presence in clinical simulation experiences suggests anxiety levels for students may decrease with faculty presence shifted to a control room or remote viewing location (Horsley & Wambach, 2015). Yet, increased anxiety as a result of faculty presence in clinical simulation experiences did not detrimentally impact clinical performance, self-confidence or satisfaction with the learning experience (Horsely &

Wambach, 2015). While these findings apply specifically to traditional to 'in person' clinical simulation learning experiences within a physical simulation lab environment, they may provide some insight for virtual simulation experiences taking place via telehealth.

In this pilot simulation experience via telehealth, faculty did not facilitate any structured feedback from the standardized patient for the interprofessional student team. The faculty facilitated debriefing session at the conclusion of the standardized patient simulation focused on culling feedback from students on their experience within an interuniversity interprofessional team and within the virtual meeting space of telehealth. While this feedback was invaluable and helps inform the next iteration of this this work, future simulations may benefit from structured feedback for the student team from the standardized patient. Feedback from the standardized patient may provide: 1. insight on team performance (Eppich, Howard, Vozenilek, & Curran, 2011), 2. authenticity of the telehealth experience (Yudkowsky, Valdes, Raja & Kiser, 2011), 3. level of interprofessional professionalism demonstrated by students (Holtman, Frost, Hammer, McGuinn & Nunez, 2011), 4. impressions of rapport established by the interuniversity interprofessional team (Graves & Doucet, 2016), 5. skills demonstrated related to motivational interviewing specifically as they apply to treating patients with history of substance abuse such as opioid addiction (Carroll et al, 2006) , and 6. feedback related to key human factors necessary for successful telehealth visits such as telehealth etiquette (Haney, Kott, & Fowler, 2015). Standardized patients perform an integral role in the training and development of health professionals. In the realm of a simulation experience via telehealth their structured feedback to address these specific areas may significantly enhance the learning that occurs for both individual health professions students as well as the overall interuniversity interprofessional team.

As health professions educators continue to refine and improve the overall simulated learning environment to include specific encounters via telehealth, it may be helpful to pair with IT/Web/App developers to develop tech solutions for live telehealth experience for interprofessional team training. In this particular pilot study we were limited by the available technology that was compatible across all universities involved. This required multiple students at each site to connect and communicate with other sites and the standardized patient via one video/audio feed. This made it difficult to identify individual participants as they spoke up to engage with their team members and the standardized patient. Additionally not all sites were visible on the screen at all times making the fluidity and continuity of connection a bit fragmented at best. The secure virtual meeting platform utilized is designed to enlarge the screen presentation of the speaking participant making other participants smaller or not visualized at all when they were not speaking. We suggest the development of a secure virtual meeting platform, to meet IRB requirements, that is designed to specifically facilitate telehealth visits between patients and an interprofessional team of providers where individual team members may access the visit from disparate remote locations. Visual presentation that reflects a 'hub and spoke' where the patient/standardized patient is at the center of the screen at all times with a 'name tag' at the bottom of their screen surrounding to screenshots of every team member with their 'name tag/role' located at the bottom of their screen.

Interprofessional Education

The various clinical factors were well addressed by the student team members who also displayed a strong sense of inter-professional practice. Professional roles were not well known by all team members and often overlapped, especially in terms of key psychosocial issues vital to addictions treatment. Although students did not note this, lack of role knowledge and overlap may have resulted in students failing to participate fully, leaving decisions to others who were more vocal or articulate. Despite this lack of role knowledge, the students did well in deciphering their roles while collaborating as a team. In this particular group there were a multiplicity of mental health and case management roles whose perspectives are an advantage in addictions treatment. However, capitalizing on this advantage requires coordination and appropriate communication strategies.

Limitations

This was a pilot study and will necessarily need adjustment for large scale curriculum adoption. The case study focus should be adjusted to ensure full participation by all professions, especially for the complicated but vital opioid addiction case genre which can be a challenge to students without previous exposure or experience with this patient population. Faculty organizational, coordination and preparatory efforts could all be improved for efficient case study facilitation and delivery. A tremendous amount of faculty time was invested to train a fairly modest number of students. Even so, faculty recommended reducing the number of students even more. Telehealth technology made it possible to convene such a broad array of professional students, resources, and faculty, but the technology and equipment did differ at each site, making communication halting on occasion.

Conclusions

The combination of telehealth technologies with inter-professional education strategies has the potential to bring vital resources to bear to solve the particular problem of opioid addiction in rural and resource-limited settings. Engaging inter-institutional, collaborative faculty enhances health education, exposing health professions students to varying geography, culture, and resources. Providing students with inter-professional tools to communicate and plan treatment in the context of the opioid epidemic will expand resources as these students go on to their respective practices, rural or otherwise. The multiple modalities and comprehensive resources elaborated in inter-professional practice, combined with telehealth technology--and in the case of Virginia, a motivated political environment--ensure substance addicted patients can get the help they need in resource-limited environments.

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Student Population Awareness and Utilization of University Provided Mental Health Resources

Julia Jackson, Liberty University Department of Public Health
Connor Weisman, Liberty University Department of Public Health
Bethesda O'Connell, MPH, DrPH, CHES, Liberty University Department of Public Health

Abstract

Purpose: A study done at a mid-sized American University assessed the student population's awareness and utilization of university provided mental health resources.

Methods: The study was completed using a survey of students with multiple choice, true/false and free response questions. Data were analyzed for any significant correlations.

Results: The results of the study provide a groundwork for future research despite limitations. The research showed that most of the students, including seniors, did not know many of the mental health resources offered on campus and had important misconceptions, such as thinking the counseling office was part of the student conduct office.

Conclusion: Efforts are needed to increase student awareness of mental health resources on campus and further study should be done to investigate the determinants of misconceptions.

Introduction

Most mental health issues first onset before the age 24 making it important for college students and non-college attending peers to be aware of mental health resources (Hunt & Eisenberg, 2009 and Eisenberg, Hunt, Speer, & Zivin, 2011). It is reported that 41% of 18-24 year olds in the United States currently attend a college or university, with serious psychological issues affecting over 17% of those students (Sontag-Padilla et al., 2016). Many college campuses throughout the United States provide some level of mental health resources to their students, be it in the form of face-to-face counseling or through the campus clinic. Despite this ease of access, over one third of college students with mental health issues do not seek treatment (Sontag-Padilla et al., 2016), limiting their ability to succeed during their time of higher education. There are many barriers that prevent students from seeking treatment including self-perceived stigma (Watson, Corrigan, Larson, & Sells, 2007) and public stigma (Wang, Peng, Li, & Peng, 2015;Hunt & Eisenberg, 2009). Public stigma is typically defined as “the negative stereotypes and prejudices surrounding mental illness held collectively by people in a society or community” (Wang et al., 2015) and is typically one of the biggest barriers a student must overcome to seek treatment (Sontag-Padilla, 2016). Self-perceived stigma is then defined as the internalization of public stigma, whether present or not, which can lead to a breakdown of self-esteem and self-efficacy. Awareness of resources within a university setting is also a huge barrier to help-seeking for mental health issues.

The main research objectives of this project include investigating awareness the university students have of provided mental health resources within their campus community and evaluating any significant correlation between demographics, awareness and utilization of those resources.

Methodology

Prior to starting the study, approval was obtained from the local institutional review board. Students from a mid-sized American university were randomly recruited throughout the university campus during normal academic hours. The recruiting locations were on the university campus in the student center, the main classroom building, the science building, the library and outside of the convocation center. These are areas of high student traffic, selected to obtain the desired number of responses in the necessary time. An effort was made to recruit students throughout all academic classes and disciplines. Students were approached by student researchers and asked if they would like to be involved in the study. After recruitment, informed consent was obtained from all participants prior to completing the questionnaire. All participants then completed the questionnaire through an online Google form-based survey on one of two Microsoft Surface tablets provided through the supporting academic department.

Participants were included in the study if they were over the age of 18 and a current residential undergraduate student at the university. Participants who did not meet these criteria were excluded from the study.

Data were collected in November through December 2017, with 101 surveys being completed in that time frame. Of those, 99 surveys met inclusion criteria and were included in the study. All participants completed a demographic questionnaire asking residential student status, gender, year of study, marital status, and race. All participants then filled out a true/false table with six statements regarding mental health services on campus. Based on their pre-existing knowledge of these services they were expected to mark the statements true or false to the best of their ability. All participants were asked if they had utilized campus mental health services. The options for this question are as follows: Yes, I currently use them; Yes, I have in the past; No, but I have considered it; No, I would not utilize them.

Results

All (100%) of respondents were over the age of 18 and all (100%) of respondents were single (unmarried). 41 respondents were male and 58 were female (Table 2). Furthermore, 17 freshmen, 11 sophomores, 20 juniors, and 51 seniors responded (Table 3). Regarding race, 78 respondents were Caucasian, 10 were Hispanic or Latino, 2 were Asian or Pacific Islander, 6 were African America, 1 was African (not African American), and 2 chose not to specify their race (Table 4).

Table 1: Demographic Data

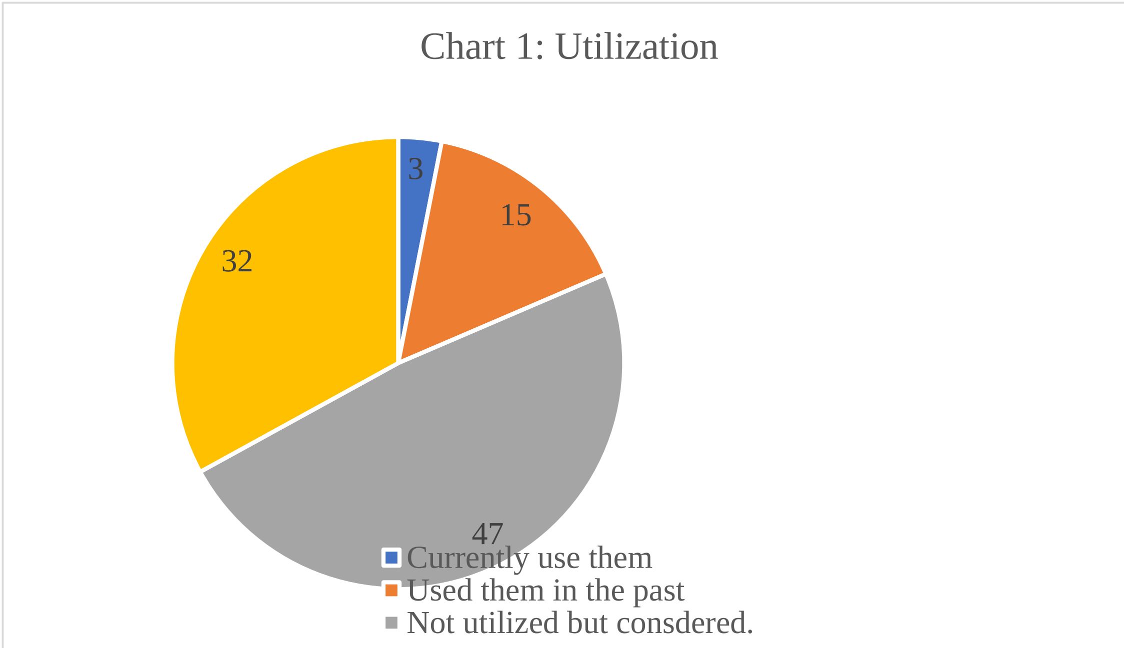
Demographic	n	%
Gender		
-Male	41	41.4
-Female	58	58.6
Year of Study		
-Freshman	17	17.2
-Sophomore	11	11.1
-Junior	20	20.2
-Senior	51	51.5
Race		
-Caucasian	78	78.8
-Hispanic/Latino	10	10.1
-Asian/Pacific Islander	2	2.0
-African American	6	6.1
-African (not African American)	1	1.0
-Other (not specified)	2	2.0

The next question analyzed the respondents' awareness of what mental health services the university provided using a true/false response table with six statements. This table only had one false statement, "Counseling office is part of student conduct office" and 69 respondents considered this true with only 29 aware the offices are separate.

Table 2: True/False Data Responses

Counseling Service Provided	True	False	Statement True	% Correct
Online mental health screenings	73	25	Yes	74%
Face to face counseling	98	1	Yes	98%
Counseling free of charge to university students	95	3	Yes	95%
24/7 mental health crisis services	79	20	Yes	80%
Counseling office is part of student conduct office	69	29	No	30%
Counseling is confidential from the rest of campus operations	91	8	Yes	92%

The next question, asking about the respondents' utilization of mental health services, showed that 3 currently used the services, 15 had used them in the past, 47 had not utilized them but had considered it and 32 respondents would not utilize them.



The final question was a free response asking respondents if they were aware of any mental health services not previously mentioned in the study. Out of the survey respondents, only 11 answered correctly.

Gender, year of study, and race were not found to have any statistically significant correlation to the utilization of services.

Discussion

The main goal of this study was to investigate the awareness students have of mental health resources provided by their university. Furthermore, through this survey there was a desire to understand and evaluate any correlations between race, gender, year of study, awareness and service utilization. In the end, this project successfully investigated the awareness of mental health services on campus 65% of respondents being aware of the services provided in some capacity. Almost 50% or respondents, however, had considered using but had not yet utilized the services. There are a multitude of possible reasons for this and further investigation is needed. However, based on prior research of college student's attitudes towards mental health services this high percentage of students considering help could be due to public of self-perceived stigma surrounding the use of the resources. Through the course of the survey, there were a few respondents who verbalized concern that the necessary anonymity did not exist between the counseling office and the rest of campus operations as it should. This however needs to be verified with further research.

Limitations

This study had significant limitations. The population size was smaller than the initial study design intended. Due to time constraints and limited resources the population was reduced to 100 respondents out of a population of approximately 15,000. More significant conclusions could have perhaps been drawn with a larger population. Furthermore, the geographical parameters of the study excluded a large part of the campus population. Despite the study being designed for undergraduate residential students on the campus, only students from the academic section of campus were included in the study. Locations not utilized included recreational areas, athlete facilities, and campuses away from the main campus.

Recommendations

As noted above, there are numerous indications for further research. A study on the internalized attitudes toward mental health services would help better understand the reason for the non-utilization by the campus population. Also, a study looking at perceptions towards mental health and how religious students seek help would provide an even better understanding of public or self-internalized stigma.

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Metal Fumes from Welding Processes and Health Impact

Shobha Subedi, School of Community and Environmental Health, Old Dominion University
Anna Jeng, School of Community and Environmental Health, Old Dominion University
Danielle Bush, School of Community and Environmental Health, Old Dominion University

Abstract

Welding processes generate significant occupational and environmental pollutants and hazards. The common pollutants from the welding processes include metal fumes, particulate matter and gas by-products. Epidemiological studies have shown a number of health effects on welders from short-term and long-term exposure to welding fumes. This article is the first to integrate scientific results, mainly from epidemiological studies, focusing on metals from different welding processes associated with well-studied and emerging diseases/health conditions. An understanding of possible adverse health effects of exposure to welding metal fumes is important to develop prevention strategies that benefit and impact workers' health.

Introduction

Welding joins materials together by melting a metal work piece along with a filler metal to form a strong joint. Welding provides a powerful manufacturing tool for the high-quality joining of metallic components. Common welding processes include shielded manual metal arc

Welding (MMAW), gas metal arc welding (GMAW), flux-cored arc welding (FCAW), gas tungsten arc welding (GTAW) and others such as submerged, arc welding, plasma arc welding, and oxy-gas welding.

Depending on process and metals, gas or alloy used, all welding processes produce visible smog, fume, aerosols, particulate matter, and nanoparticles that contains harmful metal fume and toxic gas by-products. Most of the materials in the welding fume come from the consumable electrode. A small fraction of the fume is derived from spattered particles and the molten welding pool. Welding fumes could be partially volatilized in the welding process. The composition and the rate of generation of welding fumes are affected by the welding current, shielding gases and the technique and skill of the welder. As shown in Table 1, the generated fumes and dusts ranged from 0.2 to 45 mg/m^3 in welders breathing zone depending on the process type. However, fume concentrations generated during welding were much higher, for example, it was 95.07 mg/m^3 in ventilation exhausts (Mansouri et al., 2008). This shows the importance of a well-ventilated workplace, personal protective equipment and respirators for welders. The sizes of the particles in the fumes and dusts could be smaller than 0.50 µm in aerodynamic diameter (Jarnuszkiewicz et al., 1966; Lannefors & Akselsson, 1977). Recent studies also showed that many of the individual particles were in the ultrafine size range (0.01 to 0.10 µm). When mass-size distribution of welding fumes was studied during SMAW and GTAW techniques, it was found that 60% of total welding fumes consist of particulate matter size greater than 10 µm and 39.7% of the fume consists of PM<10 µm (Yang, Lin, Young, & Chang, 2018).

Table1. Fume or dust levels in the ambient air of welder's workplace

Concentrations (mg/m^3)	Process type	Reference
0.63 − 5.90	Shielded Metal Arc Welding	Boelter, Simmons, Berman, & Scheff, 2009; Schoonover, Conroy, Lacey, & Plavka, 2011; Boelter et al., 2009
2.1 − 45	Gas Metal Arc Welding	Cena, Chisholm, Keane, & Chen, 2015; Cena, Chen, & Keane, 2016; Mansouri et al., 2008; Vandenplas et al., 1995
0.12 − 24.3	Flux Cored Arc Welding	Matczak & Przybylska-Stanislawska, 2004; Goller & Paik, 1985
1.8 − 19.0	Electric Arc Welding (Iron oxide fumes concentration)	Liu, Wong, Quinlan, & Blanc, 1995; Mansouri et al., 2008
8.67	Plasma cutters	Dryson & Rogers, 1991
0.474 − 35.2	Metal Arc welding	Pourtaghi G. et al.,2009; Bertram et al., 2015; Schoonover et al., 2011, Olivera Popovic et al., 2014
0.5 − 4.29	Soldering fumes	Matczak, 2002; Hartmann et al., 2014
0.14 − 10.7	Stainless steel welding	Stanislawska, Janasik, & Trzcinka-Ochocka, 2011
0.2-23.4	Manual Metal Arc welding	Golbabaei et al., 2012; Matczak & Chmielnicka, 1993
0.8-17.8	Metal Inert Gas welding (Aluminium)	Matczak & Gromiec, 2002

Welding fumes and dust are particularly known for the inclusion of metals and metal oxides.

Welding fumes are derived from combustion and contain a mixture of metal oxide particles. Mild steel generates welding fumes mainly consisting of iron and manganese but stainless steel generates fumes that also contain chromium and nickel (Leonard et al., 2010). In addition, some other metals are also found in welding fumes: aluminum (Al), antimony (Sb), arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), silver (Ag), tin (Sn), titanium (Ti), vanadium (V) and zinc (Zn). Gas flame, electric arc, laser, an electron beam, friction and ultrasound are used as the source of energy for welding. Some of the metal products formed in welding when metals or electrodes get melted are: Al, Sb, As, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Ag, Sn, Ti, V and Zn. Table 2 summarizes metal concentrations in biological specimens and in the air collected in the working areas and personal breathing zone.

Aluminum. A study performed by (Hanninen, and colleagues, 1994) analyzed the aluminum in serum (S-Al) and urine (U-Al) of shipyard aluminum workers. The results of the study showed the mean S-Al concentration was 0.21 (range 0.03-0.64) umol/L and the mean U-Al was 2.8 (range 0.9-6.1) umol/L.

Antimony. A study performed by Matczak (2002), focused on air samples including personal eight-hour samples. The quantitative analysis revealed that time-weighted average (TWA) of fume concentrations for Antimony were: soldering fume < 0.035 mg/m^3. For this study, it shows the levels were safe on the day of sampling.

Cadmium. Cadmium is an element used in the manufacture of fluxes found in flux-cored electrodes. Despite its use in the welding process, however, there is a little literature information about its concentrations yielded from welding processes. A study performed by Arrandale and colleagues (2015) showed that female workers at a welding plant had urinary cadmium ranging from 0.05–0.93 μg/g.

Chromium. Chromium (Cr) commonly occurs in the fume since it is found in stainless steels and high alloy steels for welding. Cr can exit in various oxidation states when it is partly oxidized to Cr (VI) and Cr (III) during manual metal arc stainless steel welding. Both trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) have been quantified in significant quantities in welding fumes. Arrandale et al., (2015), reported that female workers at a welding plant had urinary Cr concentrations in the range of 0.03–7.71 µg/g. Another study was conducted by (Cena et al., 2015), to estimate the amount of specific metals deposited into the respiratory system of workers at two facilities. The workers wore a nanoparticle respiratory deposition sampler while performing their duties. Cr concentrations were 40-105 µg/m^3, Cr (VI) ranged from 0.5-1.3 µg/m^3. A study by Ellingsen and colleagues (2017) studied whole blood, serum, urine and blood cells. The results for chromium were: whole blood <DL-6.8 µg/L, serum <DL-6.2 µg/L and urine 0.2-19 µg/g cr.

Copper. The sources of copper include copper-coated GMAW electrodes and Cu alloys. Vaporized copper has been implicated as one of the metals present in welding fumes that causes metal fume fever. Thus, most studies include air samples of fume and the air. A study performed by Matczak and team (2002), focused on air samples including personal eight-hour samples. The quantitative analysis revealed that TWA of fume concentrations for Cu were: soldering fumes <0.003-0.034 mg/m^3, brazing fume <0.003-0.038 mg/m^3. Balkhyour & colleagues (2010) looked at the total fume and metal concentrations in the breathing zone (within 0.5M) of workers during an eight-hour shift. The mean value for Cu was 0.001–0.080 mg/m^3.

Lead. A study performed by Matczak and team (2002), focused on air samples including personal eight-hour samples. The quantitative analysis revealed that TWA of fume concentrations for Pb were: soldering fumes <0.014-0.037 mg/m^3, brazing fume <0.014-0.023 mg/$m^{3.}$ For this study, it shows the levels were safe on the day of sampling.

Manganese. Manganese (Mn) commonly occurs in most welding fumes as manganese oxide is used as a flux agent in the coatings of shielded metal arc electrodes, in the flux-cored arc electrodes, and as an alloying element used in electrodes (Villaume et al., 1979). A study performed by Matczak and team (2002) focused on air samples including personal eight-hour samples. The quantitative analysis revealed that TWA of fume concentrations for manganese were: brazing fumes <0.07-0.12 mg/m^3. Cena and colleagues (2015) conducted a study to estimate the amount of specific metals deposited into the respiratory system of workers at two facilities. They reported that manganese concentrations were 2.8-199 µg/m^3. Balkhyour & Goknil (2010), looked at the total fume and metal concentrations in the breathing zone (within 0.5M) of workers during an eight-hour shift. The mean value for Manganese was 0.010 –0.477 mg/m^3.

Molybdenum. Balkhyour & Goknil (2010) looked at the total fume and metal concentrations in the breathing zone (within 0.5M) of workers during an eight-hour shift. The mean value for molybdenum (Mo) was 0.001–0.058 mg/m^3. A study by Ellingsen and team (2017), studied whole blood, serum, urine and blood cells. The results for Mo were: whole blood 0.28-5.7 µg/L, serum 0.50-3.3 µg/L, blood cells 1.1-2.4 µg/L and urine 12-93 µg/g cr.

Nickel. Nickel (Ni) is present in stainless steel welding fumes and in Ni alloys. Currently, Ni is classified as a human carcinogen (NIOSH, 1977). A study was conducted by Cena and colleagues (2014) to estimate the amount of specific metals deposited into the respiratory system of workers at two facilities. Ni concentrations ranged 0.05-0.11 mg/m^3.

Silver. A study performed by Matczak in 2002, focused on air samples including personal eight-hour samples. The quantitative analysis revealed that TWA of fume concentrations for Ag were: brazing fumes < 0.014 mg/m^3. For this study, it shows the levels were safe on the day of sampling.

Tin. A study performed by Matczak in 2002, focused on air samples including personal eight-hour samples. The quantitative analysis revealed that TWA of fume concentrations for Sn were: soldering fume <0.15 mg/m^3, brazing fume < 0.15 mg/m^3. For this study, it shows the levels were safe on the day of sampling.

Zinc. Zinc (Zn) is present in the galvanized coating on metal. Metal fume fever occurs when the galvanized metal is heated sufficiently to vaporize zinc, thus creating a fume high in zinc oxide. A study performed by Matczak (2002), focused on air samples including personal eight-hour samples and reported the TWA of fumes contained Zn concentrations ranging from 0.003-0.025 mg/m^3.

Table 2. Metal concentrations detected in welding processes

Metals	Concentration	Sample type	Sampling location	Source
Aluminum	4-53 µg Al/L	Blood	Fumes	Elinder, Ahrengart, Lidums, Pettersson, & Sjogren, 1991
	18-29 µg Al/g	Bone	Fumes	Elinder et al., 1991
	0.3-10.2 mg/m^3	Air sample	Fumes breathing zone	Sjogren & Elinder, 1992
	15-414 µg/L	Urine	Fumes breathing zone	Sjogren, Lidums, Hakansson, & Hedstrom, 1985; Sjogren, Elinder, Lidums, & Chang, 1988
Antimony	0.035 mg/m^3	Air sample	Fumes	Matczak, 2002
Cadmium	0.05-0.93 µg/g cr	Urine	Various	Arrandale et al., 2015
	0.2–12.5 mg/m^3	Air sample	Particles breathing zone	Golbabaei et al., 2012
Chromium	0.002-0.34 µg/L	Serum	Ambient air	Ulfvarson & Wold, 1977
	40–105 µg/m^3	Air sample	Particles breathing zone	Cena, Keane, et al., 2014
	0.01-1.4 mg/m^3	Air sample	Fumes	Ulfvarson & Wold, 1977
	0.03-7.71 µg/g cr	Urine	Various	Arrandale et al., 2015
	1.2 µg/L	Blood cells	Particles breathing zone	Ellingsen et al., 2017
	0.45 µg/L	Whole blood	Particles breathing zone	Ellingsen et al., 2017
	0.35 µg/L	Serum	Particles breathing zone	Ellingsen et al., 2017
	0.024 µg/g cr	Urine	Particles breathing zone	Ellingsen et al., 2017
	140 µg/m^3	Air sample	Particles breathing zone	Golbabaei et al., 2012
Cobalt	0.04-1.44 µg/g cr	Urine	Various	Arrandale et al., 2015

Metals	Concentration	Sample type	Sampling location	Source
Copper	0.35-1.4 μg/L	Serum	Ambient Air	Ulfvarson & Wold, 1977
	0.003-0.034 mg/m^3	Air sample	Fumes	Matczak, 2002
	0.003-0.038 mg/m^3	Air sample	Fumes	Matczak, 2002
	0.001–0.080 mg/m^3	Air sample	Particles breathing zone	Balkhyour & Goknil, 2010
Lead	0-1.870 μg/L	Serum	Ambient air	Ulfvarson & Wold, 1977
	0.014-0.037 mg/m^3	Air sample	Fumes	Matczak, 2002
	0.014-0.023 mg/m^3	Air sample	Fumes	Matczak, 2002
Manganese	5–9300 μg/m^3	Air sample	Fumes	Bailey, Kerper, & Goodman, 2018; Hanley, Andrews, Bertke, & Ashley, 2015
	0.010 –0.477 mg/m^3	Air sample	Particles breathing zone	Balkhyour & Goknil, 2010
	2.8–199 μg/m^3	Air sample	Particles breathing zone	Cena et al., 2015
	0.07-0.12 mg/m^3	Air sample	Fumes	Matczak, 2002
	0.009-0.37 μg/L	Serum	Ambient air	Ulfvarson & Wold, 1977
	0.60-11.33 μg/g cr	Urine	Various	Arrandale et al., 2015
Molybdenum	0.001 –0.058 mg/m^3	Air sample	Particles breathing zone	Balkhyour & Goknil, 2010
	0.2-58 μg/m^3	Air sample	Particles breathing zone	Ellingsen et al., 2017
	0.097 μg/L	Blood cells	Particles breathing zone	Ellingsen et al., 2017
	0.088 μg/L	Whole blood	Particles breathing zone	Ellingsen et al., 2017
	0.042 μg/L	Serum	Particles breathing zone	Ellingsen et al., 2017
	0.048 μg/g cr	Urine	Particles breathing zone	Ellingsen et al., 2017
Nickel	0.0007-0.16 mg/ m^3	Air sample	Fumes	Ulfvarson & Wold, 1977
	10–51 μg/m^3	Air sample	Particles breathing zone	Cena, Keane, et al., 2014; L. G. Cena et al.,2015
	50 μg/m^3	Air sample	Particles breathing zone	Golbabaei et al., 2012
Silver	0.014 mg/m^3	Air sample	Fumes	Matczak, 2002
Tin	0.15 mg/m^3	Air sample	Fumes	Matczak, 2002
Vanadium	0.02-0.68 μg/m^3	Air sample	Particles breathing zone	Kucera et al., 2001; Ellingsen et al., 2017
	0.025 μg/L	Blood cells	Particles breathing zone	Ellingsen et al., 2017
	0.035 μg/L	Whole blood	Particles breathing zone	Ellingsen et al., 2017
	0.025 μg/L	Serum	Particles breathing zone	Ellingsen et al., 2017
Zinc	0.003-0.025 mg/m^3	Air sample	Fumes	Matczak, 2002; Matczak & Chmielnicka, 1988
	76.12-621.34 μg/g cr	Urine	Various	Arrandale et al., 2015

Health effects of metals from welding fumes

Exposure to welding fumes has been associated with both short-term and long-term health effects. The degree of health risk from welding fumes depends on the composition, concentration and length of exposure. Common short-term effects which occur after four to twelve hours of exposure are eyes, nose, chest and respiratory tract irritation, thirst, fever, muscle ache, fatigue, nausea, coughing, and gastrointestinal effects. Welders experience problems like sensitive skin, as well as eye and ear morbidity symptoms due to a lack of proper use of PPE and training (Alexander et al., 2016). A high dose of cadmium in welding fumes can be dangerous for short-term exposure. Long-term metal fumes exposure effects may cause respiratory, reproductive and neurological diseases (Nemery, 1990). Long-term exposure to welding may lead to risk of skin cancer or other dermatological problems on exposed skin areas (Heltoft et al., 2017).

Respiratory effects: Over the last several decades, numerous studies have addressed and studies have been done on the effects of welding fumes on respiratory systems. The effects include pulmonary function, metal fume fever, bronchitis, pneumoconiosis and fibrosis, lung cancer, respiratory infection and immunity. Metal fume fever, caused by the inhalation of freshly formed zinc oxide fumes, is the most frequently observed welders' acute respiratory illness, a relatively common febrile illness of short duration that may occur during and after welding duties. Hassaballa and colleagues (2005), reported a 25-year-old person's metal fume fever case raised concerns that the welder could develop several respiratory complications within a few days after inhalation of metal fumes. Another study conducted by Vogelmeier and team (1987) reported that during the exposure to metal fumes, Zn levels and peripheral leukocytes were elevated as body temperature rose. Also, significant alteration in lung function occurred as evidenced by a fall in respiratory vital capacity and arterial oxygen partial pressure (Vogelmeier et al., 1987). A later study suggested that pulmonary responses of inflammatory cells may play a large role in metal fume fever (Blanc et al., 1993).

Welders are at higher risk for respiratory infections (Marongiu et al., 2016). There is increased chance of pneumococcal infection in welders (Grigg et al., 2017), and the risk is higher in welders who smoke (Wong et al., 2010). Also, excess mortality rate due to pneumonia has been reported among welders in several studies. For example, Coggon and team found a significant increase in mortality from pneumonia among welders (Coggon et al., 1994). Such increased mortality associated with respiratory infections could be due to cell-mediated immunity deficiencies and cytotoxic activity of immune cells caused by welding fume exposure (Tuschl et al., 1997; Boshnakova et al., 1989).

The effects of welding fumes on the pulmonary function of workers has been commonly examined over the last two decades. Sobaszek and team (2000) examined the acute respiratory effects of 144 stainless steel welders and 223 controls at the start and end of a work shift. The welders had experienced a significant decrease in forced vital capacity due to a sensitization of the respiratory tract by Cr. A more recent study examined lung function of 1982 workers during 2002-2010 occupational health check-ups and reported that a decrease in lung function was caused by occupational exposure to welding fumes and smoking habit (Haluza et al., 2014). Smoking habit may confound the results of pulmonary function tests in welders (Chinn et al., 1990).

Welding fumes have been categorized as a possible human carcinogen (Group 2B) [IARC, 1990, 1993], as the fumes contain dangerous carcinogenic metals, e.g. Cd, Ni and Cr(VI) ("Chromium, nickel and welding," 1990). Rachelle Beveridge and colleagues conducted case-control studies among two populations from 1979 to 1986 and 1996 to 2001 with 1598 cases and 1965 controls. They collected detailed job histories to identify their occupational exposure to metals including nickel, chromium and cadmium (Beveridge et al., 2010). They reported that lung cancer risk was increased only to former smokers or non-smokers.

However, a recent random trial by Wong and colleagues on 2034 participants shows that longer working years in the welding field and foundry work are related to an increase in risk of lung cancer among heavy smokers (Wong et al., 2017). 2,034 lung cancer cases had incident lung cancer out of a random trial among 53,454 heavy smokers. Medically/histologically confirmed cases from 2002-2009 along with duration of exposure to metal fumes were accessed by questionnaires. This study supports the evidence of exposure to metal fumes or welding may be related to an increase in lung cancer risk. Similarly, in a cohort study by Siew et al. of all working age-group Finnish men who took part in a census in 1970 were followed by the Finnish cancer registry for lung cancer cases (1,971-1,995). This study supported that cumulative exposure to welding fumes and iron is related to increased lung cancer risk, mainly squamous cell carcinoma (Siew et al, 2012). Metals, e.g. Cd and Ni in welding fumes could induce the formation of DNA-protein cross-links, which could influence the initiation and promotion of cancer. Also, inappropriate covalent DNA-protein cross-links can disrupt gene expressions and chromatin structure and may lead to the deletion of DNA sequences (Costa et al., 1993).

Renal disease: If chronic exposure to metals from welding fumes can induce nephrotoxic effects is still controversial. Epidemiological studies have not consistently suggested an adverse effect on renal function (Vyskocil et al., 1992; Verschoor et al., 1988). However, increasing reports have shown an association between certain metals from welding fumes and nephrotoxicity. For example, a total of 103 Chinese welders had significantly increased urinary b2-microglobulinaemia levels, a biomarker of renal tubular dysfunction, after exposure to airborne cadmium from 5 to 86 mg/m^3 in the personal breathing zones (Ding et al., 2011). Also, exposure to metal fumes increased renal intestinal alkaline phosphatase expression and oxidative stress in welders (Hambach et al., 2013). A recent study, which used ECM-receptor interaction-related biomarkers for renal injury, kidney injury molecule (KIM)-1 and neutrophil gelatinase-associated lipocalin (NGAL) to assess nephrotoxicity, reported that the levels of those biomarkers increased in welding worker post-exposure and were significantly associated with urinary Al, Cr, Mn, Fe, Co and Ni levels in welders (Chuang et al., 2015).

Reproductive system: Sexual dysfunction is also one of the major complains of welders. A cross-sectional study on 35 stainless steel welders, 46 mild steel welders and 54 non-welding metal workers showed that sperm count and motility were significantly decreased in mild steel workers (Bonde, 1990a). Another study (conducted before and after three weeks of non-exposure among metal workers and welders) by Bonde warns us that welding may cause non-reversible effect on semen quality (Bonde, 1990b). Questionnaires from 242 congenital malformation cases and 270 controls revealed that the chance of congenital malformation was higher in the child if the father was exposed to welding fumes during periconceptional period (El-Helaly et al., 2011). However, a longitudinal, multi-country study of parents of 24,168 offspring aged 2-51 years found that the father's pre-conception welding was independently associated with non-allergic asthma in their offspring and the father's smoking habit before conception may be a factor for the increased risk of offspring asthma (Svanes et al., 2017). Also, radiant heat exposure for a long time during welding could be a confounding factor for decreased sperm quality and fertility of male welders (Bonde, 1992). Male workers exposed to manganese also have symptoms of sexual dysfunction (Bowler et al., 2007).

Emerging health issues

Central nervous system: Welders may be at increased risk of neurological and neurobehavioral health effects when exposed to metals such as Pb, Fe, Al, and Mn. For example, welders with long time exposure to Mn, Al or Pb experienced neuropsychiatric symptoms (Sjogren et al., 1990). 12 welders with exposure to Al had decreased motor function, including reaction time, finger tapping speed and endurance, vocabulary, and tracking (Sjogren et al., 1996). In addition, aluminum from welding fumes associated with symptoms of decrease in memory and concentration problems along with fatigue and depressions too (Riihimaki et al., 2000). However, short time exposure to Al showed no neurological system effect even if the concentration was higher. Psychomotor function abnormalities have been observed in hemodialysis patients who had a history of welding and exposure to Al (Sjogren & Elinder, 1992). Recent studies indicate neurological and neurobehavioral deficits may occur when workers are exposed to low levels of Mn (<0.2 mg/m^3) in welding fumes (Bowler et al., 2007). These effects include changes in mood and short-term memory, altered reaction time, and reduced hand-eye coordination (Bowler et al., 2007; Antonini et al., 2006).

The mechanisms of the effects of metals from welding fumes on the central nervous system is still unclear. However, recent animal studies reported that Mn can reach the brain through brain microvascular endothelial cell, olfactory and trigeminal nerve and crossing choroid plexuses to cerebrospinal fluid and final up-to brain (Yokel, 2009).

There is a complaint about sleep disorders by welders exposed to heavy metal fumes in comparison to office workers who have less awake time throughout the night (Chuang et al., 2018). There is a behavioral change in long term welders (Lee et al., 2016) and fatigue, mild depression, and memory and concentration problems (Riihimaki et al., 2000). Some research indicates that there may be an effect of heavy metals like aluminum on short-term memory, learning and attention (Hanninen et al., 1994), along with decrease in other cognitive performance (Akila et al., 1999). Increase in welding fume exposure causes increase in Cd levels in urine and can cause renal tubular dysfunction (Ding et al., 2011). Increase in manganese exposure during the welding process can also be a strong link for decrease in memory, attention, concentration, learning abilities, cognitive abilities and visual problems (Bowler et al., 2007). Additionally, participants present symptoms like sleep disorders, headache, sexual dysfunction, insomnia, slurred speech, tremors, etc. (Bowler et al., 2007). A case study of a 5-year-old boy with symptoms of anorexia, irritability, vomiting, mental confusion, insomnia and abnormal movements warns us about not only occupational exposure but also environmental exposure to welding fumes (Cury et al., 2017). The boy had a history of three months in a new house adjacent to a welding garage, and he had blood Pb level of 27 µg/dL. However, this case study does not discuss previous environmental exposure, if any, but his symptoms lasted 15 days and a neurological examination along with MRI showed right hemiparesis, generalized myoclonus, impaired swallowing and grasp reflex.

Sleep disorders and depression: There is increasing attention on the effect of pulmonary exposure to metal fumes fine (<2.5 µm) particulate matter ($PM_{2.5}$) on sleep disorders (Bureau of Labor Statistics U.S. Department of Labor, 2015; Shen et al., 2018). Earlier studies showed an association between welding fumes and sleep disorders. For example, a case report showed that workers exposed to welding fumes containing Mn presented with symptoms of sleep disturbances, olfactory, extrapyramidal and mood disturbances (Bowler et al., 2011; Bowler et al., 2007a). Furthermore among 43 bridge welders, 79% had sleep disturbances (Bowler et al., 2007b). According to Bowler and team (2007), TWA of Mn in air ranged from 0.11-0.46 mg/m^3 in a study of 43 welders working in confined spaces with indicated symptoms like excessive fatigue, sleep disorders, toxic hallucinations, depression and anxiety. More recent studies have further advanced our understanding of metals in welding fumes playing a critical role in sleep disorders. Chuang and colleagues (2018) reported that welding workers had greater awake times than did office workers. They further suggested that exposure to heavy metals in metal fume $PM_{2.5}$ may disrupt sleep quality in welding workers and an imbalance of serotonin by personal $PM_{2.5}$ with metals could be the cause for sleep disorders. Serotonin is one of the most important brain chemicals regulating the sleep/wake cycle (Portas et al, 2000). An increase in 1 µg/m^3 of personal $PM_{2.5}$ exposure was found to associate with a decrease of 0.001 ng/mL in serotonin in welding workers. Lower levels of serotonin were reported to result in sleepiness and to cause sleep disturbances, depression, and chronic fatigue syndrome (Portas et al., 2000). However, more studies are needed to confirm the cause.

Parkinson’s disease: Recent studies on how welding fumes affect neurological systems suggested that welding fumes could increase the risk for Parkinson’s disease. Exposure to welding fumes may damage dopaminergic neurons in the brain, raising the welders' risk for Parkinson's disease. A longitudinal cohort study of 886 welders followed up to 9.9 years after baseline measurements showed the progression of Parkinson’s disease increased with cumulative Manganese exposure. The exposure was associated with hands bradykinesia (slow movement), limb rigidity and impairment of facial expression and speech (Racette et al., 2017). Another study supports the finding by demonstrating that in a study of healthy welders exposed to Mn, positron emission tomography imaging showed reduced uptake of the tracer F-18-fluoro-L-dopa, a sign of dysfunction in nigrostriatal neurons in welders who may have had occupational exposure to high levels of manganese (Criswell et al., 2011).

Cardio-vascular diseases: Evidence accumulating from epidemiological studies indicates an association between the exposure to welding fumes and increased risks of cardiovascular events, e.g. cardiac arrhythmia, myocardial ischemia and atherosclerosis (Cavallari et al., 2007; Chinn et al., 1990). A study by Brook et al. shows that even short-term inhalation of fine particulate matter causes arterial vasoconstriction on healthy adults (Brook et al., 2002). This warns us about the cardiovascular risks to welders as they get continuously exposed to metal fumes. Cavallari and colleagues showed that metal fumes exposure of boilermaker construction workers to $PM_{2.5}$ caused alterations in heart rate variability (Cavallari et al., 2008). Fang and colleagues did a study on 26 males after exposure to welding metal fumes and their results showed that exposure to $PM_{2.5}$ evokes adverse vascular changes (Fang et al., 2008). Umukoro and colleagues observed that long-term metal particulate exposure can decrease cardiac accelerations and decelerations in welding workers (Umukoro et al., 2016). In a cross-sectional study, interviews and biological sampling conducted on 101 welders and 127 controls in southern Sweden, it was found that there was an increase in blood pressure among welders in comparison to the control group (Li et al., 2015). A longitudinal study from 2001-2010 in Rome suggested that long-term exposure to metal PM2.5 µm is found to contribute to mortality mainly from ischemic heart disease (Badaloni et al., 2017).

Conclusions

Epidemiological studies have generated some scientific data revealing health effects of fumes from welding processes on welders' health. However, scientific data on metal in welding fumes is still limited. Those epidemiological studies performed in different worker populations, industrial settings, and welding techniques. Also, most of those studies lack a well-defined exposure assessment to determine duration of metal exposure and to quantify inhalable and biological response doses. Epidemiological results have consistently shown an association between exposure to metal fumes and respiratory effects, including bronchitis, airway irritation, lung function changes and a possible increased risk of lung cancer. However, possible underlying mechanisms and causality remain less clear regarding inhalation of metal welding fumes. Also, determination of dose-response of metals in fumes has posed a challenge due to a mixture of toxicants in welding fumes and availability of well-defined populations. Finally, few studies have addressed the non-respiratory effects of metals in welding fumes, although increasing results over recent years have become available showing the reproductive, renal and dermal effects. A few specific metals in welding fumes, such as Mn and Al have been found to associate with neurological effects when inhaled in high concentrations. However, whether those metals can cause neurological problems remains unanswered. Some emerging health effects have been examined including Parkinson's disease, cardiovascular disease, sleep disorders and depression. Health impacts caused by metals in welding fumes remain an important health issue for welders. More epidemiology studies are needed to provide a better understanding of health effects caused by exposure to metals in welding fumes.

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Use of Infant Vitamin D Supplementation among Women Attending a Local Special Supplemental Nutrition Program for Women, Infants and Children (WIC)

Sina Gallo, RD, PhD, Department of Nutrition and Food Studies, George Mason University
Janine A. Rethy, MD, MPH, Obesity and Chronic Disease Prevention, Loudoun County Health Department
Amara Channell Doig, MPH, Department of Nutrition and Food Studies, George Mason University,
Jennifer Brady BS, Obesity and Chronic Disease Prevention, Loudoun County Health Department
David Goodfriend, MD, MPH , Loudoun County Health Department

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Abstract

Purpose: Breastfeeding without adequate vitamin D supplementation may predispose infants to vitamin D deficiency and rickets. The aim of this report was to determine the percent of women attending a local WIC program who met the infant vitamin D recommendation and to explore determinants of supplementation.

Methods: A cross-sectional de-identified survey was completed, via an online platform, by a sample of women attending two district clinics. The survey collected information concerning the respondent's youngest child on infant feeding at 3 months, vitamin D supplementation and knowledge. Meeting the vitamin D recommendation was defined as either receiving 400 IU daily through supplementation, consuming 32 oz. of infant formula or a combination of both.

Results: Among a sample of 163 women (72% Hispanic), 28% reported giving their infant a vitamin D supplement and 31% met the recommendation. Mothers who reported receiving recommendations from a health care professional were 26-times more likely to provide vitamin D supplementation (95 % CI: 5, 135, p<0.01).

Conclusions: Use of infant vitamin D supplementation was low in this predominately Hispanic sample of mothers. Counseling greatly affected vitamin D supplementation yet; most reported not receiving education from health care providers. Further research is warranted among a larger sample.

Introduction

As per the American Academy of Pediatrics (AAP), all infants receiving less than 32 oz. of vitamin D fortified formula per day are recommended to be supplemented with 400 IU of vitamin D daily from birth (Wagner & Greer, 2008) to prevent bone diseases such as rickets. There appears to be a worldwide re-emergence of rickets with noteworthy increases since 2000 (Prentice, 2013). Immigrant minority children appear at higher risk (Goldacre, Hall, & Yeates, 2014) possibly due to decreased reliance on cutaneous synthesis in sunny home countries when they move to more northern latitudes. Although rickets prevalence is not tracked in the US, children with darker skin color, born to a mother who is vitamin D deficient and breastfed without supplementation are at high risk (Bergström, Blanck, & Sävendahl, 2013; Thacher et al., 2013). Despite the many benefits to breastfeeding for both the mother and offspring (Eidelman et al., 2012), vitamin D content of breastmilk is limited (við Streym et al., 2016).

Vitamin D supplementation promotes bone health as children, who were vitamin D deficient, and received supplementation improved their bone mass (Winzenberg, Powell, Shaw, & Jones, 2011). Moreover, current vitamin D recommendations by the Institute of Medicine do not specifically consider non-bone health outcomes associated with vitamin D deficiency including cancer, obesity, and mental health diseases (Institute of Medicine, 2010). Vitamin D deficiency in infancy has been linked to increased respiratory tract infections and asthma (Feng et al., 2017); and supplementation may offer protection for type 1 diabetes (Zipitis & Akobeng, 2008). Although there appears to be a lack of consensus on the definition of optimal vitamin D (Holick et al., 2011; Institute of Medicine, 2010), it is clear that circulating levels <30 nmol/L (12 ng/ml) are associated with deficiency and bone diseases, yet suboptimal vitamin D status may be associated with a range of morbidities and constitute a larger public health concern.

Adherence to the AAP infant vitamin D supplementation recommendation is low in the US. Only 27% of all infants participating in the National Health and Nutrition Examination Survey (NHANES) 2009–2012 met the vitamin D supplementation recommendation (Ahrens, Rossen, & Simon, 2016) and infant supplementation use was only 16% among a large pediatrician network in Seattle, WA (Taylor, Geyer, & Feldman, 2010). Comparisons are difficult to interpret as usual dietary and supplement intake must be accounted for including vitamin D content of formula as well as infant age.

Purpose

Breastfeeding without adequate vitamin D supplementation may predispose already at-risk children to vitamin D deficiency and rickets (Thacher et al., 2013). Since 2009, the Special Supplemental Nutrition Assistance Program for Women, Infants and Children (WIC) has instituted a number of policies to incentivize breastfeeding (Whaley et al., 2012), yet there is a paucity of data on the proportion of infants who receive vitamin D supplementation and meet the recommendation among this group. More importantly, understanding what influences parental behavior regarding vitamin D supplementation particularly among ethnic minority populations will help inform policy and practice. Therefore, the primary aim of this study was to determine the percentage of infants meeting the AAP infant vitamin D recommendation as defined by use of vitamin D supplement, or total amount of vitamin D intake equaling or exceeding 400 IU/day. The secondary aim was to explore the barriers and facilitators to supplementation among a sample of mothers attending a local district WIC program.

Methods

Design

The design was a prospective cross-sectional de-identified self-report survey completed online in WIC waiting rooms. This design was appropriate to assess the prevalence of vitamin D supplement use among our target group. Study procedures were approved by both George Mason University and the

Virginia Department of Health's Institutional Review Boards. All responses were anonymous and de-identified. Informed consent was obtained.

Setting

WIC is a federal food assistance program which targets low-income, nutritionally at-risk women and children aged 0–5 years of age in the US; 53% of US infants are served by WIC. The program provides supplemental foods, education/counseling as well as screening/referrals to other health care professionals. Breastfeeding rates among WIC participants nationally are 32% (13% full, 19% partial) and 43% (10% full, 33% partial) in the local district where the study was conducted (U.S. Department of Agriculture (USDA), Food and Nutrition Services (FNS), 2017).

Sample

The target population was a convenience sample of women attending a local district WIC program. The sample inclusion criteria were adult women (≥18 years), able to understand English or Spanish and having a child aged ≤ 60 months (based on WIC eligibility). Overall 190 participants completed the survey; however, 27 were excluded (n=11 missing child age, n=16 child aged ≥60 months). The final sample size was 163. A sample size of 143 participants would be required to obtain a 95% confidence interval of ± 7.5% around a 30% estimate of use (Ahrens et al., 2016) based on vitamin D supplementation use.

Measurement

The survey collected information about household health and access to assistance programs, food and physical activity habits although, this report focuses solely on results from the infant vitamin D supplementation practices and knowledge section. Survey questions were written at a 5th grade level, closed-ended and based upon protocols and recommendations from the AAP and Academy of Breastfeeding Medicine (ABM). Both the Loudoun County Health Department and George Mason University Department of Nutrition and Food Studies were involved in the development and analysis of the survey. Bilingual WIC staff reviewed and pilot-tested both English and Spanish versions of the survey to ensure consistency and clarity (Grawey, Marinelli, & Holmes, 2013). The majority of survey respondents in this local district report Spanish as their primary language; hence, the survey was only provided in English and Spanish. Food insecurity was defined based Hager et al., 2010 (Council on Community Pediatrics & Committee on Nutrition, 2015).

Survey respondents were asked to best describe their youngest child's infant feeding during their first 3 months as: breastfed only, formula fed only or mixed feeding (included mostly breastfed and mostly formula fed). These definitions were based on WIC food package categories ("Breastfeeding," n.d.) and ABM (Eidelman et al., 2012). Vitamin D supplementation practices including vitamin D intake from supplementation and formula was calculated based on information about supplementation frequency and information about average amount of formula intake at 3 months. The 3-month time point was selected as formula fed infants may not be receiving sufficient amounts of formula (<32 oz/day) to meet vitamin D needs and thus, are also vulnerable to deficiency. Respondents were classified as meeting the AAP recommendation if their child achieved 400 IU of vitamin D daily through supplementation, by consuming 32 oz. of infant formula or a combination of both. Questions about knowledge of vitamin D sources as well as sun exposure were also included.

Data collection

Information was gathered from women attending two local clinic waiting rooms (Loudoun county, VA) between June–August, 2016. The survey was administered on-site using an online survey platform, Qualtrics (2016, Provo, UT) and completed on portable devices (iPads). Bilingual study staff were on site to administer consent and survey, and to answer questions. No incentives were provided for survey completion; respondents were informed that their survey responses would be used to help improve community health services.

Statistical analysis

Mean (SD) was reported for descriptive continuous variables (maternal and child age, number of children) and n (%) for categorical variables (gender, education, race, ethnicity, country of birth, income, prenatal vitamin taken, feeding type [formula, breastfed, both], vitamin D recommended by a health professional). Continuous variables were compared using Student t-test or Mann Whitney U for non-normally distributed data and chi-square (Fisher's exact for small samples) for categorical variables. Predictors of vitamin D supplementation practices were explored using logistic regression models and presented as odds ratio (95% CI). Data were analyzed using SAS version 9.3 (Cary, NC) and statistical significance was set at $p \leq 0.05$.

Results

Table 1 describes demographic characteristics of survey respondents. There were no significant differences in demographics among respondents who met vs. did not meet the vitamin D recommendation (data not shown). Respondents consisted of ~9% (n=190) of all families enrolled in this local WIC agency at the time of the survey; however, only data for respondents with a child aged ≤ 60 months were included in this report (n=163). The median age of the respondents' youngest child was 10 months. Overall, the majority of respondents self-identified as Hispanic, the most common country of birth was El Salvador, and 65% reported Spanish as their primary language. Food insecurity was high as 51% reported being worried about running out of food over the last year.

Vitamin D supplementation practices at 3 months of age are shown in Figure 1. Overall, 28% of respondents reported using infant vitamin D supplementation and 31% met the AAP recommendation when their child was 3 months of age. The percentage of respondents who reported supplementation differed by infant feeding group ($p<0.01$) — supplementation was reported by 46% of the exclusively breastfed group compared to 23% of mixed group and 4.5% of the exclusively formula fed group. However, there was no difference in the percentage of respondents who achieved the AAP recommendation by group. Based on those who reported giving their infant a vitamin D supplement, the mean age of starting supplementation was 1.5 months, and 23% of respondents introduced vitamin D supplementation before 1 month of age, as per the AAP recommendation.

Overall 43% of respondents were aware of the recommendation to give vitamin D daily and 38% of respondents reported receiving advice from a health care provider about vitamin D supplementation. Among those who received the vitamin D recommendation, 79% of respondents reported that it came from a physician, 17% from a WIC breastfeeding counselor, 2% from a nurse, and 2% from a nutritionist. The most common reasons for not giving a vitamin D supplement was that their physician did not recommend it (n=45), WIC did not recommend it (n=18), or they believed it was not necessary (n=18). Having a health care professional recommend vitamin D supplementation predicted a 26-times increased likelihood of vitamin D supplementation (95 % CI: 5, 135, $p<0.01$) (Table 2). When asked about the best source of vitamin D, 18% identified a vitamin D supplement while 64% reported that sun exposure is the only vitamin D source their child needs.

Discussion

In this study population group a large majority of infants were not receiving supplemental vitamin D. Lack of provider counseling regarding AAP vitamin D recommendations was reported as the main reason for non-adherence which may be putting these infants at high risk for deficiency and associated co-morbidities. Although our sample had a higher rate (33%) of breastfed infants (exclusively and mixed) meeting the vitamin D recommendation compared to a national NHANES sample (19%), there was a much lower rate for formula fed babies (e.g., 10% compared to 31% nationally) (Ahrens et al., 2016). Differences in data collection methods may explain these discrepancies. Our results were based on vitamin D estimated formula intake at 3 months, which is likely less than the necessary (e.g., 32 oz. per day to obtain 400 IU of vitamin D). Consistent with previous research (Perrine, Sharma, Jefferds, Serdula,

& Scanlon, 2010), our results suggest most infants, not only exclusively breastfed, will likely need to receive supplemental vitamin D. More respondents of exclusively breastfed infants reported supplementation, which suggests that mothers of formula fed infants may not be receiving the same messages as mothers of breastfed infants. In addition, we identified a lack of health care education regarding infant vitamin D supplementation as a main reason for not supplementing among our sample.

Vitamin D supplementation adherence rates in the US have historically been much lower than other countries — 74% of breastfed infants in Canada received supplementation (Health Canada, 2012) and good adherence (≥80% of infants) was reported by 59% of European countries surveyed (Uday, Kongjonaj, Aguiar, Tulchinsky, & Högler, 2017). Lack of parental education by health care professionals may explain these differences as physician' knowledge of the AAP recommendations has been positively associated with the likelihood of their recommending vitamin D supplementation (Sherman & Svec, 2009). Consistently, our results found that having a health care provider —physician, nurse, nutritionist — recommend supplementation predicted a 26-fold increased likelihood of supplementation. Another US study found only 36% of providers were recommending vitamin D (Taylor et al., 2010). The current study's survey results further confirm these results, showing incomplete knowledge and adherence to AAP infant vitamin D supplementation recommendations among primary care providers. Reasons for this may be due to lack of recognition of rickets as a concern, area and location of training as well as misconceptions regarding sun exposure (Shaikh & Alpert, 2004; Sherman & Svec, 2009). In addition, limited time during a physician visit for nutrition counseling highlights the important role of other health care professionals in supporting parental education regarding vitamin D sources and recommendations.

WIC nutritionists and breastfeeding counselors may be untapped resource for educating and supporting infant vitamin D supplementation. WIC does not provide vitamin D supplementation to families.

Vitamin D is an approved Medicaid supplement, which requires health screening and prescription by a provider for coverage. Although only 3 respondents in our sample found cost to be a deterrent to supplementation (data not shown), this issue needs to be further explored as food insecurity was high in this sample. A Turkish program to promote infant's vitamin D supplements, including free drops at health centers, found improvements in both infant vitamin D status and decreased rates of rickets (Hatun, Ozkan, & Bereket, 2011). Improving access to vitamin D supplementation alone (Millette et al., 2014) does not appear effective in increasing supplementation rates, without appropriate and tailored education (Madar, Klepp, & Meyer, 2009). Most participants (82%) in the present study were unable to correctly identify the best sources of vitamin D, which is an education gap and should be addressed. In addition to education on infant recommendations, different supplement preparations (alcohol vs. oil based), costs/insurance coverage, and supplement delivery methods for primary care providers could be included as part of WIC breastfeeding counseling. There is a need for more research to support the effectiveness of vitamin D education and possibly provision programs in the WIC setting.

Limitations

This study explored use of infant supplemental vitamin D among an understudied population (Furman, 2015). The data presented here are preliminary, do not represent all mothers participating in the WIC program and are limited in their lack of cultural specificity. Limitations of this survey include reliance on mother's memories and the possibility of recall bias although, previous work found good concordance of maternal recall of breastfeeding up to 6 years later (Amissah, Kancherla, Ko, & Li, 2017; Cupul-Uicab, Gladen, Hernández-Avila, & Longnecker, 2009). For the current survey, although the age of respondents' youngest children ranged from 0.5 to 48 months, the median age was 10 months. Reliability and validity of the survey were not tested. Although respondents' ability to correctly understand the survey may have biased results, questions were written at a 5th-grade level, and bilingual WIC staff reviewed and pilot-tested both English and Spanish versions of the survey. Results may have been biased by respondents who provided socially acceptable responses; social acceptability was not assessed, but results concerning the percentage of respondents who reported supplementation overall and by infant feeding group (Figure 1A) do not seem to support a socially acceptable bias.

Conclusion

Low use and poor knowledge of infant vitamin D supplementation recommendations were found among women attending a local WIC program. Results also suggest exclusively formula fed younger infants may not be obtaining sufficient amounts of vitamin D. The advice of a health care provider had a significant positive effect on use, and results suggest a gap in healthcare providers providing that advice. Health care providers may benefit from concise and targeted education and accessible educational materials to assist them. Further research is warranted among a larger sample of mothers of infants as well as to explore challenges of supplementation from the perspective of both providers and users.

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Table 1. Respondent characteristics, presented for all (n=163)

Characteristic	Mean ± SD or n (%)
Mother's age, years	30.4 ± 7.2
Youngest child age, months[a]	10 [0.5, 48]
<3 months	15 (9.2)
3 to 6 months	31 (19.0)
6 to12 months	55 (33.7)
12 to 24 months	38 (23.3)
24 to 48 months	24 (14.7)
Child gender, male	84 (51.5)
Number of children[a]	2 [1, 7]
Education, highest level completed	
Elementary school (<6 years of education)	24 (15.4)
Some high school (7-11 years of education)	44 (28.2)
High school (includes GED, college, bachelor's and advanced degree)	88 (56.4)
Race	
American Indian/Alaska Native	3 (2.4)
Black/African American	17 (13.6)

White	23 (18.4)
Asian	6 (4.8)
Other	75 (60.8)
Ethnicity	
Latino/Hispanic	115 (72.3)
Non-Hispanic	44 (27.7)
Mother's country of birth (based on UN geographic region classification M49)	
North America[b]	38 (24.2)
South America	10 (7.0)
Central America and Caribbean (includes Mexico)	85 (54.1)
Other (Africa, Asia, Europe)	24 (14.6)
Federal poverty level[c]	
≤ 100%	97 (80.8)
>100%	27 (19.2)
Prenatal supplement taken during pregnancy	149 (94.9)

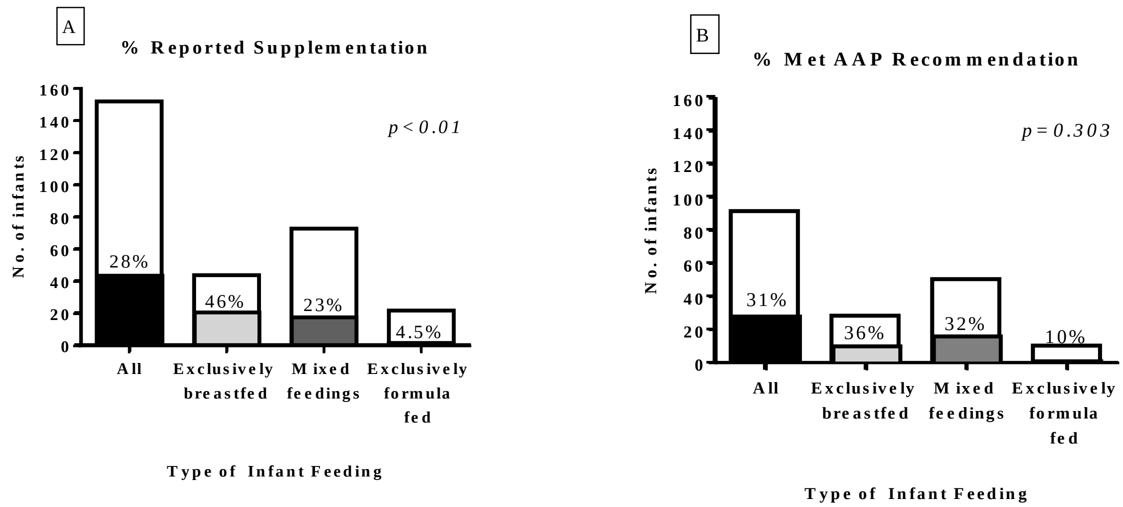
GED refers to General Equivalency Diploma; AAP refers to American Academy of Pediatrics
[a]Non-normally distributed data presented as median [range], analyzed using Mann Whitney U (nonparametric) test.
[b]All were US
[c]Based on family income and number of people in household, for 2017 see: https://aspe.hhs.gov/poverty-guidelines

Table 2. Logistic regression model to identify factors associated with achieving AAP infant vitamin D recommendation, based on daily supplementation and/or average amount of formula at 3 months (n=74)[a]

Predictor / Explanatory Variables	Odds Ratio	95% Confidence Interval
Maternal age, years	1.02	0.91, 1.14
Number of children	0.75	0.41, 1.34
Education, highest level completed (reference = High school or greater)		
Elementary school	0.40	0.04, 3.83
Some high school	0.65	0.15, 2.81
Country of birth, North America (reference = Outside North America)	3.18	0.69, 14.60
Infant feeding type, 3 months (reference = Exclusively breastfed)		
Mixed feeding	2.10	0.50, 8.82
Exclusively formula fed	1.19	0.09, 16.70
Health professional recommended (reference = not recommended)	26.0	5.00, 135.0
R^2=48.4%		

Note. AAP refers to the American Academy of Pediatrics.
Infant vitamin D recommendation refers to Wagner & Greer, 2008.
[a]Sample limited to n=74 (n=25 achieved AAP recommendation, n=49 did not achieve AAP recommendation) as proc logistic procedure excludes any observations with missing values for the explanatory variables

Figure 1. A) Percent of total respondents who reported giving infant vitamin D supplementation, by infant feeding at 3 months (n=152)[a‡], B) Percent of total respondents meeting AAP recommendation (Wagner & Greer, 2008), based on daily supplementation and/or average amount of formula at 3 months, by infant feeding at 3 months (n=91)[a‡].



[a]Sample size reduced for presentation by infant feeding groups: n=13 missing; [b]n=3 missing; [‡]Statistical significance reported in figures refers to differences by infant feeding groups.

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Questions: Contact Dr. David Sallee at dsallee@radford.edu