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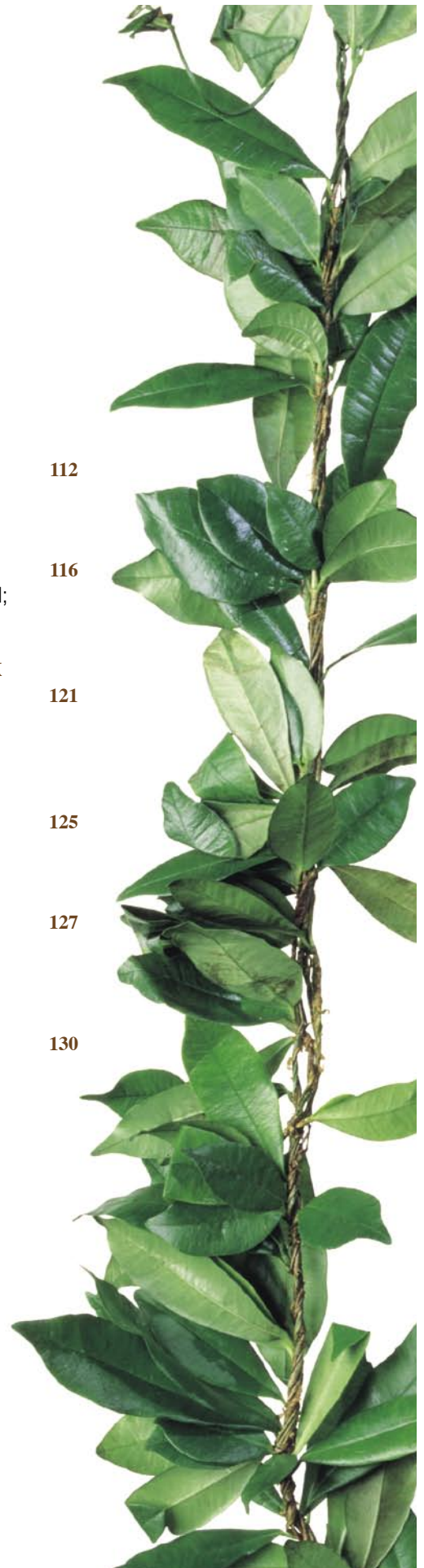
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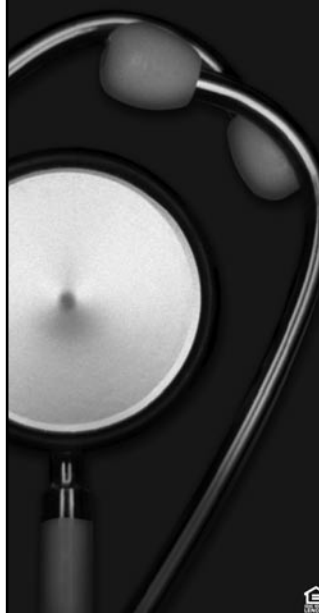
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Improving Toxicology Knowledge in Preclinical Medical Students Using High-Fidelity Patient Simulators

Brunhild M. Halm MD, PhD; Meta T. Lee MD, MEd; and Adrian A. Franke PhD

Abstract

Background: Superior patient care and optimal physician training are often mutually elusive in the Emergency Department setting. High-fidelity patient simulators (HFPSs) are being used with increasing frequency in the training of medical students (MS) because they enable students to develop and refine medical competency in a non-threatening and safe environment. However, learner outcomes using HFPSs in this setting have not been well studied.

Objectives: The objective of this pilot study was to determine the effectiveness of HFPSs in simulation (SIM) training as a learning tool for preclinical second-year MS to further increase their toxicology knowledge.

Methods: Second-year MS at a Problem Based Learning (PBL) medical school received a PBL toxicology teaching session in the middle of the semester. One week later, the students participated in a SIM exercise based on issues taken from the PBL case. The SIM exercise required that students address learning issues such as identifying abnormal findings, ordering tests, and, ultimately, initiating treatment on a full-scale HFPS mannequin. A supervised on-line test consisting of 10 multiple choice questions regarding the student's understanding of the learning issues was completed before the PBL class and directly before and after the SIM to determine the effectiveness of the HFPS use. Immediate video-assisted feedback was provided by emergency medicine attendings.

Results: Use of HFPSs during SIM exercises and in combination with PBL significantly increased toxicology knowledge in second-year MS as determined by the improvement of on-line test scores (% correct answers) from 59% before PBL / before SIM to 69% after PBL / before SIM to 80% after PBL / after SIM.

Conclusion: This study suggests that HFPS may be a valuable tool in helping to improve toxicology knowledge in second-year MS at a key transition period prior to beginning clerkship experiences. Incorporation of HFPS into PBL curricula may also be beneficial to MS in other areas of study where interactive learning could assist in evoking emotional realism while also enhancing critical thinking and acquisition of knowledge thereby facilitating the transition from theory to practice.

Introduction

High-fidelity patient simulators (HFPSs) are computer controlled life-size mannequins externally and internally constructed to allow multisystem physiological real-time changes to occur in response to human intervention. HFPSs are appealing in the medical field because they have the ability to evoke emotional realism to a situation in a non-threatening manner.¹ For that reason, HFPSs are being increasingly employed in the training of physicians, nurses, medical students (MS), and many other healthcare professionals.²

The practice of learning medicine without placing a patient at an increased risk of complications is of utmost importance. While it would be ideal for MS to learn from their mistakes in real-life situations, in reality, MS are commonly prevented from doing so as attending physicians are ethically bound to stop such erroneous actions. However, learning from mistakes is highly effective in acquiring factual knowledge.³⁻⁵ Therefore, learning the consequences when making an error is ethically justifiable using an HFPS as opposed to an actual patient.⁶

Advances in computer-enhanced simulation technology have led to the development of many medical management algorithms and given MS the opportunity to experiment and learn medicine in a risk free and fairly realistic environment.⁷ Using medical management algorithms, realistic clinical scenarios can be created and tailored to individuals such that specific skills can be practiced repeatedly. Through simulation (SIM) training laboratories, preclinical MS become familiar with clinical equipment and procedures. SIM laboratories also introduce MS to the use of physiological monitoring instruments (e.g. HFPSs) and help to integrate clinical decision-making in a non-threatening environment. SIM training is especially important for first and second-year MS because, at this stage, formal learning is very limited in the hospital and MS often feel insufficiently prepared for clinical practice in the clerkships.^{8,9}

There are few studies which directly address SIM training for preclinical MS in an emergency department setting. Most trials are observational studies or self reported satisfaction questionnaires involving a small number of participants.⁷ A few articles address objective evaluation of learning strategies of preclinical medical students.^{10,11} The subjective response of MS regarding SIM exercises are clearly positive.¹²⁻¹⁵

The objective of this pilot study was to determine the effectiveness of HFPS use during a SIM training exercise among preclinical second-year MS. More specifically, this study was aimed at determining whether toxicology knowledge and confidence in preclinical second-year MS could be improved by augmenting a PBL case with a SIM exercise using an HFPS. Learning objectives for the students were to identify and act upon abnormal vital signs in a semi-conscious overdose victim, and recognize the signs and symptoms of opioid toxicity.

Methods

Study Setting and Population

Fifty second-year MS at a Problem Based Learning (PBL) medical school participated in this study. One week before the SIM exercise, the students studied a toxicology PBL case as part of their required preclinical curriculum. The PBL case featured a semi-conscious adolescent female who overdosed on acetaminophen. Learning issues for the case included: identifying normal/abnormal vital signs, workup and management of patients with poisoning, clinical features of toxic states, and the differential diagnosis of altered mental status.

Four weeks before the SIM exercise, the students spent time with a clinical instructor familiarizing themselves with the laboratory layout, laboratory equipment, and a full-scale HFPS Laerdal SimMan mannequin (Laerdal Medical Corporation, USA). This mannequin was used in a previous teaching session involving bag-valve mask ventilation and would also be used for the current SIM exercise. Details about the setting, the available resources, and the tasks at hand for the SIM exercise were explained to the students.

The Committee on Human Subjects at the University of Hawai'i determined that this study was an exempt educational study.

Study Design and Measurements

Prior to implementation with the second-year MS, the toxicology SIM exercise was piloted among four third-year MS, revised with input from several attending physicians, and then finalized. Faculty were trained to observe students and provide immediate feedback after each SIM exercise.

For the current SIM exercise with the second-year MS, a medical management algorithm was constructed by the Principal Investigator (BMH) and was based on core concepts identified by the course director. The algorithm was programmed into the HFPS mannequin such that adverse physiologic responses would occur if a student did not complete an expected task in a timely fashion. A wall-mounted video camera was used to record student performance during the SIM exercise and to assist in constructive feedback after the SIM exercise.

Before studying the PBL case, the students completed a supervised on-line test consisting of 10 multiple-choice questions. The purpose of the test was to determine the student's baseline understanding of the learning issues for the PBL case; eg, normal and abnormal vital signs, toxicology, and the management of a semi-conscious individual that overdosed.

After studying the PBL case and before the SIM exercise, the students completed a second online test identical to the first one they had just taken along with a 4-question survey regarding their level of self-confidence in treating acutely sick patients in a clinical setting. Upon completing the test and survey, groups of 3 to 4 students were then given 30 minutes to complete the SIM exercise using the mannequin. For the SIM exercise, a PBL case was provided on a computer screen and featured a semi-conscious adolescent female who was found next to her bed with an almost empty bottle of acetaminophen and then taken to the emergency department by paramedics. Students were instructed to collaborate in groups of 3-4 to discuss the clinical care of the victim, including history at the bedside, physical examination, monitoring of vital signs, generation of a differential diagnosis, and initiation of workup and therapy. The students considered basic interventions such as providing bag-valve mask ventilation, starting an intravenous line, ordering tests and intravenous fluids, and giving medications. The mannequin was programmed to react appropriately to the student's interventions, eg, a decrease in oxygen saturation would occur if bag-valve mask ventilation was not started within 5 minutes, or an increase in blood pressure would occur if intravenous fluids were given. All SIM exercises were video recorded for playback during post-session debriefing. The emergency medicine physician debriefing the students was present during the SIM exercise and provided additional patient history if requested.

After the SIM exercise, the students received a 20-30 minute debriefing session in which constructive feedback was provided from emergency medicine attendings with the help of the computer facilitator and video playback. The attendings were instructed not to discuss any of the online test questions during the debriefing session. The students were not aware of the algorithm programmed for the SIM exercise nor did they know they would be receiving the same online multiple choice questions repeatedly. The students were asked

not to discuss the test questions or SIM exercise amongst each other during the study phase and were assured that they would not be graded. Immediately following the debriefing session, the students completed another online test identical to the previous two online tests, another self-confidence survey, and a course evaluation.

Data Analysis

Data were analyzed by paired student's t-test and single-factor (parametric) analysis of variance (ANOVA) using Excel 2004 software (Microsoft, Redmond, WA) and were presented as mean \pm standard error (SE). Differences at $p < 0.05$ were considered significant.

Results

Evaluation of the 10 identical online multiple-choice questions (Q1-10; see Figure 1) completed among the 50 students before PBL and before SIM (stage 1; S1) *versus* after PBL and before SIM (stage 2; S2) *versus* after PBL and after SIM (stage 3; S3) revealed an overall significant improvement in correct answers from S1 to S2 (59% to 69%; $p < 0.05$), from S2 to S3 (69% to 80%; $p < 0.05$), and logically also from S1 to S3 using ANOVA and individual paired t-tests.

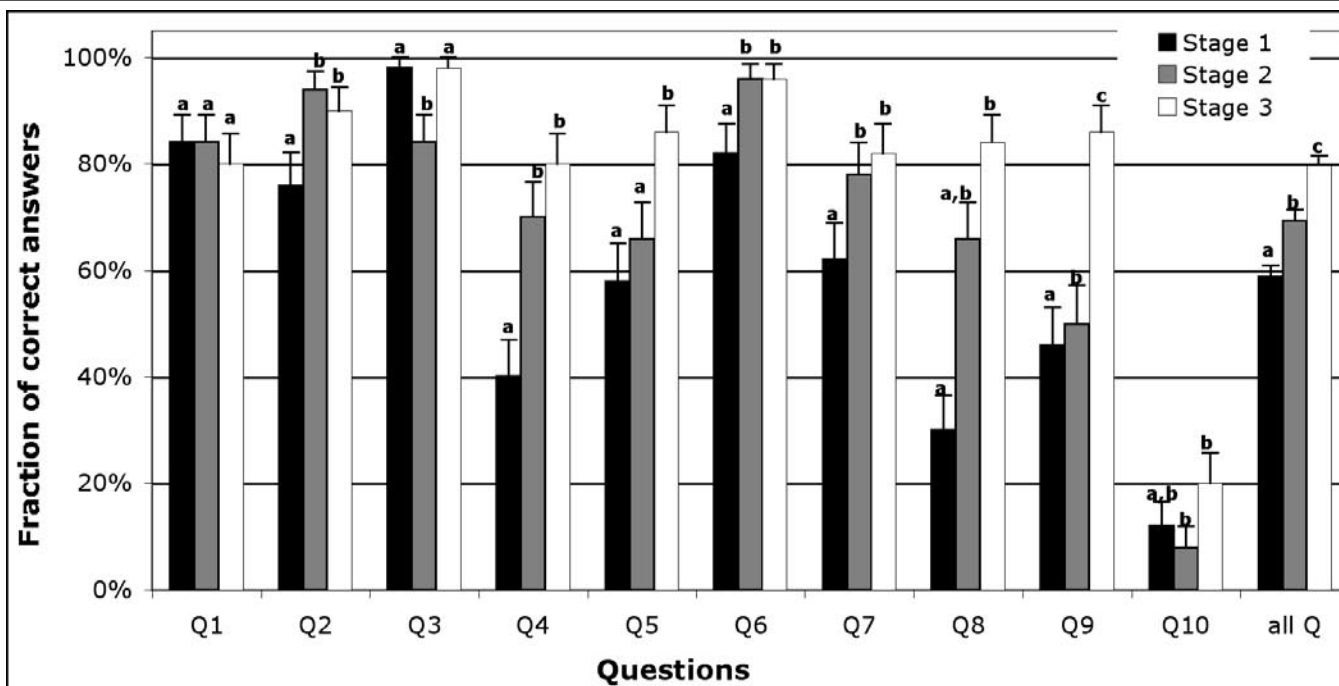
A trend showing improvements in knowledge for the online questions between each stage (S1-S3) was also observed except for Q1 and Q10, which exhibited no changes in knowledge between all stages. These two questions tested the students on the topics of identifying normal/abnormal vital signs and the treatment of morphine overdose, respectively. The only topic with a worse score at S2 was signs of codeine overdose (Q3). However, scores at S3 showed a level of knowledge on this topic similar to that at S1 (Figure 1). Among the 10 topics tested, students scored worst in the treatment of morphine overdose (Q10) with 8-20% correct answers while all other correct answers ranged between 30% and 96% (for details, see Figure 1).

In addition, the mean confidence level for performing basic life support (BLS), evaluating a patient with drug overdose, managing a semiconscious patient and treating a patient with an acute toxic ingestion increased from 2.5 to 3.3 using a 5-point Likert scale (1-very low to 5-very high) after the SIM exercise compared to before the exercise.

Discussion

Results from this pilot study suggest that SIM exercises may be a valuable tool in helping to improve toxicology knowledge in pre-clinical second-year MS at a key transition period prior to beginning clerkship experiences. Although the clinical experience is simulated, this approach can help to produce a level of emotional realism and urgency in MS thereby forcing them to reason through critical decisions that they may encounter in real-life. This is logical since learning by doing and being allowed to make mistakes enhances critical thinking and acquisition of knowledge.³⁻⁶

For some learners, simulation may allow complex information to be understood and retained more efficiently compared to PBL alone. The PBL curriculum at our institution emphasizes self-directed learning and, in this classroom setting, first and second-year MS work cooperatively in groups of 5 to 6 to solve a series of cases on paper containing specific health care problems. In this educational model, students determine their own learning agenda based on the problems identified in each paper case. Of note, MS nearing the end of their second year tend to be very focused on independently



Error bars indicate standard error. Different letters among bars for each question represent significant differences.

Q1: Normal/abnormal vital signs

Q2: Signs of crystal methamphetamine overdose

Q3: Signs of codeine overdose

Q4: Difference between a sympathomimetic and an anticholinergic overdose

Q5: Class of drugs causing dilated pupils

Q6: Role of primary survey

Q7: Interpretation of an ABG

Q8: Assessment of breathing in Basic Life Support

Q9: Complications of bag mask ventilation

Q10: Treatment of morphine overdose

Figure 1. Mean Knowledge Questionnaire Results

studying basic science material for their upcoming national board examination. To generate greater interest in studying more clinically relevant issues, our faculty integrated the current SIM exercise into the existing PBL curricula in order to “bring to life” existing case material from the PBL classroom thus facilitating the transition from theory to practice. Course evaluations revealed that our SIM exercise was extremely well perceived by the students, which is consistent with other reports across the disciplines.¹²⁻¹⁷

While popularity should not define the usefulness of an educational experience, we believe that if learning medicine can be made enjoyable for MS, it can spark their interest to learn and, therefore, the experience would be valuable. In fact, some educators suggest that HFPSs may accelerate the acquisition of knowledge due to the emotional power of the simulated encounter. The findings suggest that both student knowledge and confidence increased. How this translates to actual performance in the Emergency Department setting would be of additional importance, but is beyond the scope of this study.

The learning objectives addressed in the SIM exercise were identical to those studied in the PBL case one week prior to the SIM exercise. In order to learn effectively, the environment needs to be both participatory and interactive. A SIM exercise is a teaching method that requires learners to think and react on a minute-to-minute basis. It requires learners to apply theory to practice in an

integrated manner. Therefore, SIM exercises may be more effective than passively reading a textbook or listening to a lecture.^{18,19} They can be easily integrated into PBL curricula to facilitate the transition from theory to practice.

Although all students participating in the SIM exercise were certified in Basic Life Support during their first year of medical school, their knowledge did not improve in identifying normal/abnormal vital signs after the PBL session or after the SIM exercise (Q1). The findings from this SIM exercise experience support our belief that second-year MS do struggle with applying knowledge learned from textbooks and classroom settings. As such, SIM exercises requiring the use and application of BLS with focus on normal/abnormal vital signs could be a valuable teaching tool for MS at this stage of learning.

The subjective response of MS regarding SIM exercises was unanimously positive. The twenty-four comments submitted from students in the course evaluation were all positive. Such comments included: “this was a great experience since it combined both theoretical knowledge of medicine with actual application,” “great job overall in terms of real-life scenario and complexity of simulation,” “the feedback at the end of the simulation was very helpful and pointed out where we had missed important steps or tests,” “Outstanding, more sim labs please.”

Students also found the feedback session by the emergency medicine physicians to be a useful teaching strategy. The authors designed the SIM exercises so that learning would occur through “hands-on” experience with the mannequin as well as through faculty feedback in the debriefing session. Although this study was not designed to quantify which portion of the SIM experience resulted in greater learning, studies suggest that students who receive a feedback debriefing session during SIM exercise display significant increases in performance compared to students who do not receive feedback.²⁰

Limitations

Perhaps the greatest limitation in the current report is the repetition of test questions between sessions. Since the questions from the second and third test were identical to the first, it is possible that, after the first test some students may have looked up or discussed the questions and/or answers amongst each other. If so, this could have resulted in the increase in correct test answers before, but less likely after the SIM exercise. Because there was no control group in this study, it is difficult to conclude that the SIM exercise, rather than the additional teaching exercise resulted in the improvement of test scores.

Nonetheless, due to the short time span between the PBL case and SIM exercise (1 week), it is reasonable to assume that, after studying the PBL case, knowledge on the learning issues were already maximized and that the additional increase in knowledge thereafter (eg, increased test scores between sessions) was the result of the SIM exercise.

In conclusion, this pilot study suggests that incorporating HFPS into SIM exercises may be valuable in increasing knowledge and self-confidence in preclinical second-year MS during their key transition period prior to beginning clerkship experiences. Faculty who are interested in using SIM should recognize that an emphasis on decoding normal/abnormal vital signs may be important at this stage of learning. More extensive research is needed to look at long-term effects of simulation interventions in the preclinical setting in regards to retention of knowledge and acquired skills.

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Cost-Benefit Estimates of an Elderly Exercise Program on Kauaʻi

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and Lorrin Pang MD, MPH

Abstract

The elderly consume a disproportionate amount of health care resources, and the recent trend in obesity will only escalate costs. EnhanceFitness® (EF) is an exercise program designed to increase the strength, flexibility, and balance of older adults. A comprehensive controlled study in Washington state of an elderly population has shown that participants who attend at least one EF class per week reduce healthcare costs by 20% per year. The present study reports the costs and potential benefits of replicating EF on Kauaʻi. For Kauaʻi the annual cost of an EF pilot program for 132 clients would be \$204,735. Attendance records of the Kauaʻi program showed that 96 (73%) of those enrolled attended at least weekly. Based on national reports of healthcare costs for the elderly, averting 20% of the costs for these 96 elderly would save \$344,256 per year. The expected investment to return ratio, I-R ratio, for EF on Kauaʻi is about 1–1.8. On economic grounds, a case can be made to support and expand these types of programs. In these times of budget cuts, cost-benefit analysis provides a common economic “language” to prioritize among different programs.

Introduction

The alarming rise in obesity rates is one of the latest symptoms associated with bad habits of our modern lifestyle. Health officials are responding with a call for lifestyle changes, including a return to more exercise and more sensible diets. When exercise programs are adhered to they significantly improve the health of everyone, including the elderly. The benefits of exercise include improvements in function¹⁻³ (balance, strength, endurance, and flexibility) and can help to prevent/improve chronic conditions such as cancer, diabetes, heart disease, high blood pressure, strokes, falls, depression, and other conditions.¹⁻⁵ Guidelines are for 2 hours and 30 minutes of moderate-aerobic activity, 75 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of both per week.⁶ Episodes should be performed for at least 10 minutes and preferably spread throughout the week. These guidelines are for adults, including older adults.

When exercise recommendations are administered as programs, they meet with poor adherence and poor sustainability.⁷⁻¹¹ In fact, in randomized controlled studies good outcomes correlate only modestly with group assignment. There is a much better correlation with whether or not exercise actually occurs (some in the intended exercise group don't comply while some in the non-exercise group exercise on their own).⁷⁻⁸ Not surprisingly, some find that adherence, rather than intention is the most important factor affecting outcome.⁷⁻¹⁰

Faced with the rising cost of health care and rising obesity rates, many try to improve the effectiveness of exercise programs by calling for better adherence rates.^{7,9-11} While this might seem easy, the reality of poor motivation is one of the key factors leading to the current crisis. Faced with this situation one is forced to be more quantitative — to ask how powerful exercise, as an intervention, really is. For those who do adhere, do they benefit enough to justify the cost of the entire program, including the non-adherers as well? Or put another way, despite poor adherence, are the benefits of exercise

powerful enough to make programs economically worthwhile even under an intention to treat model? This paper begins to address this issue.

Preventing health problems through exercise has two major economic impacts. First, healthy people continue to work and contribute to economic production. Second, preventing illness averts the cost of treating these conditions. For the elderly, many of whom are retired/semi-retired, it is hard to calculate the first economic effect. This paper only focuses on the second effect, reducing healthcare-costs through exercise. When resources are limited, it is important to prioritize recommendations based on a more quantitative economic analysis. Ideally the authors would like to show that for every dollar invested in a program, x dollars in health care costs will be averted, a cost:benefit analysis.¹² Only then can the authors begin to compare different programs on common economic criteria, weighing this against other factors such as ethical and legal issues.

“Choices for Independence” an initiative of the Federal Administration on Aging (AoA), seeks to empower older adults to stay active and healthy through Older Americans Act services, which includes evidence-based disease prevention programs. As a result of a 3-year grant from the AoA, through the Healthy Aging Partnership Program established by the State Executive Office on Aging (EOA), the County of Kauaʻi Agency on Elderly Affairs (AEA) planned and implemented the program EnhanceFitness® (EF), a group exercise program for adults at least 60 years of age. This particular program was selected because a large, controlled study shows that it lowers health costs for those with “good” adherence.¹³ This paper describes Kauaʻi's EF program, its cost and fidelity to the original program, which are critical to extrapolating results from the original study.¹⁴ A cost-benefit analysis is done. This uses the published report of “efficacy” for those who adhere to the EF program, Kauaʻi's records of clients' adherence and the cost of the Kauaʻi program. Findings and conclusion of the economic impact are presented followed by a discussion of program sustainability.

On Kauaʻi, although a one-year program had been completed at two sites, outcome data was ready for analysis from only one of these sites at the start of this study. As the program began to expand to four more sites, financial stakeholders asked for an interim estimate of the cost-benefit ratio of this program. The authors agreed to examine Kauaʻi's annual cost of running six sites and compare it to estimated averted health costs. Averted health costs depend on a threshold level of program adherence. This is tallied from only one of the first two sites for which there was data at the start of the study, (Koloa). Assuming that this site is representative of the others, one could then estimate averted cost for all the sites, a cost-benefit ratio, and make an argument for or against sustainability/expansion.

Methods

Initial discussions were held with Senior Services in Seattle, Washington to examine the protocols of EF and the requirements to implement the program. Hawaiʻi's statewide Healthy Aging Partnership Program Steering Committee and the University of Hawaiʻi (UH)

reviewed the EF protocols and fidelity components. Program planning and coordination included scheduling, participant recruitment, instructor training, and securing sites for implementation. Recruitment presentations were conducted at the first two centers, Koloa and Waimea Senior Centers, located 14 miles apart. Recruitment packets were developed that included registration, health history, and consent forms. The target date to launch the program was July 9, 2007. At each site classes were set to run three times per week and participants were encouraged to come to as many sessions as possible.

To set up six sites, a week-long statewide training was coordinated and held on Kaua'i in June, 2007 by AEA staff and trainers from Senior Services. Eight staff from Kaua'i were trained; 1 Master Trainer, who trains EF instructors and teaches classes, and 7 EF instructors who only teach classes. The authors allocated one EF instructor per site. Assessments were done at baseline and then every four months for all participants. These evaluations measured agility, balance, and upper and lower body strength. Monitoring procedures were established to evaluate each instructor for fidelity to the original EF program. The program was expected to continue as a collaboration among the AEA, County of Kaua'i Department of Parks and Recreation, Kaua'i District Health Office, Lifelong Fitness/Terri Halliday, Kaua'i Economic Opportunity, and the Kaua'i Community College Nursing Department.

This program used computer-scanable client data forms, which were developed by Senior Services of Seattle, Washington and validated by previous EF programs. Data were collected on participant demographic characteristics, attendance rates, performance measures, and program satisfaction. Physical performance was measured through Fitness Checks and includes: (1) Chair stand test for lower-body strength; (2) Arm Curl test for upper-body strength; and (3) Up-and-Go for agility and balance. These sequential assessments were analyzed using paired t-tests.

Regarding fidelity of replicating the EF program, in the beginning of the planning phase County of Kaua'i partners completed a track changes tool, which evaluated each component of the original program.¹⁵ After a review of the operational plan by Seattle staff, Kaua'i began training of local affiliates. Local instructors were continuously monitored with a standardized "fidelity monitoring tool" developed and validated by the Seattle group. One hundred and ten items in nine categories were evaluated after one week, one month, and then every 4th month. These categories were checked using 3 criteria; meets or exceeded requirements, did not meet minimum requirements, and needs improvement. After every evaluation recommendations and corrective actions were made as needed.

Cost-benefit analysis examined the dollar value of resources invested in a program compared to the resulting incremental dollar value of benefits. Since both components were in dollar amounts an investment to return ratio, I-R ratio, was calculated. For Kauai's EF program the cost of resources used to set up and operate the exercise

program at six sites was tallied. Regarding benefits, the authors used the results of a published study determining averted health care costs for those who met a minimum criteria of attendance.¹³ Next, the attendance records of the clients were examined. The authors used data from the first site to estimate how many clients at six sites could be expected to meet the criteria for "efficacy." While the key factor determining aggregate benefit was the number meeting a minimum attendance criteria, it was useful, but not essential, to describe attendance rates. This introduced questions as to how one defined the denominator, the number enrolled. The denominator was considered to be the number of subjects who ever entered the program. If clients subsequently asked to be dropped for medical reasons or lack of interest they were deleted from the denominator in subsequent tallies. The authors did not set criteria which automatically dropped clients based on the number of absences. Participants could return after long absences, including illness, and were considered "enrolled" throughout this period.

To address a key component of sustaining this program, clients' satisfaction was addressed. Towards this end two client satisfaction surveys were administered, one scannable form developed by Senior Services with 9 questions and one developed by the University of Hawai'i with 11 questions. Surveys were administered at 4 and 12 months from the start of the program. The surveys asked questions about what participants liked most and least about the program, if they would they recommend the program to others, the level of challenge in doing the exercises, satisfaction with instructor support and ability to make the class fun, and the amount of exercise on non-class days.

Results

For one of the first sites opened, Koloa, the data for the 27 participants ever enrolled was: mean age of 80 years; 26 were female; and 18% were Caucasian, 72% were Japanese, and 12% were Filipino. The prevalence of chronic diseases was as follows: arthritis (37%), diabetes (14.8%), and hypertension (48.1%).

Table 1 shows by month Koloa's number enrolled, the number of "successful" clients who attended at least one class per week, and the overall percent attendance using a maximum of three classes per week. As shown in Table 1, attendance suffered starting month 6, near the Christmas and New Years holidays, and continued for the second half of the year. Over the year the monthly average number of clients with "successful" outcomes was 16. The current program was planned to expand to a total of 6 sites for a total enrollment of 132 clients, of which the authors estimated there will be $16 \times 6 = 96$ successes.

For the Koloa site, comparing baseline to post-program measures of fitness showed the following. The mean number of repetitions of the timed chair stand test increased significantly from 10.9 to 12.7 ($P = .02$). The time taken for the up-and-go test decreased significantly from 10.7 seconds to 8.8 seconds ($P < .001$). The number of arm

Table 1

Month	1	2	3	4	5	6	7	8	9	10	11	12	Average
Enrolled	19	20	22	22	23	23	26	26	26	26	26	27	23.8
Success	16	16	16	16	16	10	18	16	17	16	14	18	15.9
Attendance	63%	63%	50%	57%	51%	34%	44%	47%	49%	44%	40%	47%	49%

curl repetitions increased from 9.1 to 10.3, but the increase was not significant ($P=0.32$). Up-and-Go test resulted in a very significant ($P<0.001$) decrease in time, from 10.7 seconds before to 8.8 after, to perform the standard routine. The satisfaction survey showed that most were greatly satisfied with the class instructor (mean score of 9.8 on a 1 - 10 scale, 10 indicates greatly satisfied), were likely to continue the exercises they had learned (mean of 9.2), and were very confident they could continue exercising regularly (mean of 8.8). Most of the participants liked the program. They reported that they liked the program because it helped them to exercise regularly, improved their health status, and enabled them to socialize. Evaluation of fidelity after one year showed that 7 (administrative functions, warm up exercises, safety, strength, balance, stretching, cool down period) of the 9 criteria met or exceeded fidelity requirements, while two (aerobics, physical set-up) needed improvement.

Cost-Benefit Analysis

The three basic components needed to determine the cost-benefit of this exercise program were **1)** the averted health costs per client, **2)** the number of clients expected to meet the criteria of a “successful outcome,” and **3)** the cost of the program.

1) The averted medical costs of successful exercise participation was based on a literature report of a large, comprehensive, non-randomized, controlled study at the University of Washington.¹³ On an annual basis, it was determined that attending classes at least once a week reduced health costs by 20.7%. No reduction was seen in those with less participation. In that study half of the subjects in the study group chosen to exercise were not “successful” in meeting the once a week participation criteria. This raises the possibility that participation itself could have selected for a healthier, subgroup of elderly – with lower baseline medical costs. Further unpublished analysis by the authors (Ackerman, personal communication) showed that this “healthy cohort” effect implies, at most, 12% lower baseline medical costs – an adjustment that needed to be made to general elderly population estimates.

The expected health costs for elderly on Kaua‘i was calculated from nationwide annual healthcare cost statistics.¹⁶ Data from 2004 showed that the average US elderly healthcare expense for the age category 75-84 years was \$16,389. Hawai‘i’s Medicare costs were only 77% that of the corresponding US Medicare cost. However, in 2004 Hawai‘i’s annual rate of increase for Medicare was 9.3%

versus about 6% for the US Medicare population, for this age group. Therefore, for the Hawai‘i population, the 2009 health costs would have been $(16,389 \times .77) \times 1.093^5 = \$19,685$. The baseline healthcare cost of those individuals fit enough to meet the program criteria of success, the “healthy cohort” effect explained previously, could have been about 12% lower than average, or \$17,323. The annual averted cost for a successful outcome would have been 20.7% of this, or \$3,586.

2) The number of expected successful clients was estimated from Table 1. The authors expected 16 of the 22 clients enrolled at each site to meet the criteria of success. For a program covering 6 sites this would total 96 successes. The total averted health costs for six sites would be $96 \times \$3,586 = \$344,256$ per year.

3) The total cost of the program to operate six sites, based on operational costs of the first site, was \$180,476 in 2004. Adjusting to 2009 with a 2.6% average rate of inflation,¹⁷ the cost would have been \$204,735. Recurrent costs were 92% of the budget and the 8%, one time, up front costs, are listed in lines 1 and 3 of Table 2. Although instructor training, line 4, might seem to be a one time cost, a conservative estimate accounts for high turnover of instructors and tallies these expenses as ongoing. An itemized list is presented in Table 2.

The investment to return (averted medical costs) ratio for the entire program was $\$204,735$ to $\$344,256 = 1$ to 1.7. Excluding one time costs, the ratio for operational costs only was $\$188,356$: $\$344,256 = 1$ to 1.8.

Discussion

A model and cost estimates are presented for an exercise program for elderly in small, local communities. This may be an efficient way to avert health care costs. The investment-to- return ratio is 1:1.8 with returns beginning the first year. One key point of health economics is that savings to society as a whole are considered first, irrespective of who pays and who saves. Are there “true gains” to be made by doing things more efficiently? In contrast, merely transferring funds from one group to another may create a false impression, at least among the receivers of funds, that “progress” is being made. This paper does not focus on who would/should make the investment and who reaps the savings. During the current economic and health crisis one

Licensing	8,000	1 time cost: \$3,000/first site; \$1,000/ea. additional site
Licensing Renewal	800	renewal for 6 sites: \$300/first site, \$100/additional
Weights	6,397	1 time cost for 6 sites
Training	4,877	New Instructor & Master Trainer, training by Senior Services (initially, turn over may be yearly)
Fees - Instructors	63,180	\$10,530 @ 6 mos. (2 instructors) x 2 x 3
Fees - Master Trainer	10,838	4/07 - 4/08
Salaries - Staff	25,121	Half-time coordinator @\$2093.40/mo. – current salary as County personnel
Admin. Supplies	1,304	\$651.91 @ 6 mos. x 2
Program Supplies	2,121	\$1060.67 @ 6 mos. x 2
In-kind	57,838	AEA staff salaries, fringe, County facility usage for sites 48198.25 @ 10 mos. = 4819.83/mo. x 12 mos.
Total \$	180,476	

should realize that most health funds eventually can be traced back to the same source. Thus, the concept of efficiency should become a main strategy rather than each agency merely seeking a larger slice of a pie of finite size. Increasing exercise is a key component of our public health response to the obesity epidemic. Although this recommendation is made almost reflexively, evaluations of exercise programs need to take into account adherence, since this is a key factor correlating to benefits.⁷⁻¹⁰ If one replicates evidence based programs and adjusts for local variations in adherence and program costs, one can estimate the economic impact, in terms of cost effectiveness or cost benefit, of such programs.

One assumes that evidence-based exercise interventions, when adhered to, will reduce baseline health costs for the elderly by an average of x%. There may be wide variations in baseline costs correlating with one's level of fitness, which in turn might correlate with one's ability to adhere to an exercise program. One weakness of this approach is that those who do manage to adhere are a self-selecting group. Their health care costs may not be similar to that of the general elderly population, for whom national data is tracked. While it is tempting to think that those who adhere have a "healthy worker" effect with lower baseline health costs, it is also possible that they are indeed less healthy with higher baseline costs, and their better adherence reflects their physicians' stronger recommendation to exercise. Therefore it may be better to simply measure health costs pre- and post-intervention, rather than try to predict adjustments to averted costs. In this study, averted costs are not actually measured. A valid measurement calls for a large rigorous study with cost standardization across different insurance programs. Small communities, such as Kaua'i, with an estimated population of 63,000, may not support this type of research. In addition, considering the rapid rise in obesity, there may be no time for such detailed studies prior to making general recommendations for exercise. Communities starting such programs before they know the costs and benefits should at least measure these parameters as they conduct their programs. In addition it is important to gather cost data, despite small numbers, on self-selecting groups.

Low attendance/adherence rates will usually be the weak link of behavior modification programs. This will affect the I:R ratio. Only 67% of study clients met attendance criteria to be considered "successful." While this is somewhat better than the 50% rate seen in the Washington study,¹³ other exercise programs fail because of lower participation. To address low attendance, some of the elderly in the present study requested more classes per week, for the sake of convenience. On the other hand, funders argue that having classes three times a week might already be excessive when the criterion for success is a minimum attendance of once a week. At some point, increasing the number of classes leads to diminishing returns. If the total number enrolled had all been successful, attending at least once a week, the I:R ratio would have been 1:2.5. One way to improve attendance without scheduling more classes is to increase enrollment beyond the 22 clients that the center can accommodate, to overbook classes – planning for a 33% absenteeism. When the actual attendance exceeds the ceiling of 22 participants, a non-supervised activity could be offered to those who had already come at least once that week.

Another way to improve adherence might be to interview clients to determine what motivates them to attend. In the current study, since sessions were scheduled away from senior center meal times, socialization, health, and exercise are the main reported reasons for attending. Other programs might consider meals, snacks, and gifts as incentives. Alternatively, it is suggested that asking participants to pay a nominal amount at the beginning of the program would result in more commitment to attend, to get one's "money's worth." These kinds of indirect incentives could backfire and flood the classes with too many clients if over-enrollment is used. One can not over-emphasize the need to study factors which affect adherence,^{18,19} bearing in mind that this study only reports adherence during the first year of the program. Participants may need additional motivation as the novelty wears off, especially because health benefits do continue beyond the first year (personal communication, Dr. Ackerman).

There are other adjustments which this analysis overlooks. The average US elderly health care costs were used in this analysis. Presumably this represents urban and rural populations. On the neighbor islands if more complex medical treatment requires interisland travel, then adjustments to averted costs need to account for travel and lodging. Thus, it may be that preventive programs on neighbor islands might be more cost effective than those run in Honolulu. The exercise program operates with trained, but non-medical, staff. As long as medical costs continue to rise faster than general wages of the staff, the I:R ratio will show rising returns. With costs rising so quickly, the study's I:R ratios probably are outdated by the time this article is printed. But even under 2009 values, this analysis shows that there are costs to be averted, savings to be made.

As explained in the introduction, estimation of attendance is based on data from only one of the authors initial sites. Although it might have been better to wait for a year's worth of data from all six sites, stakeholders wanted this interim analysis since funding priorities are important in these difficult economic times. Health officials and those who fund prevention programs are often forced to act with less than perfect information, especially when so many are calling for more physical activity. One has to balance waiting for rigorous proof of new methods to enhance adherence or taking action now. Furthermore, in today's cost conscious economy, funders are asking for best estimates of cost:benefit, the "bang for buck." This paper is submitted as an example of a methodology to approach both crises of rising obesity rates and rising health care costs. Weighed against alternative approaches one can now begin to argue if such programs should terminate, continue or expand.

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Maggot Debridement Therapy in the Treatment of Complex Diabetic Wounds

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Abstract

The growth and aging of the population of Hawai'i with a high incidence of diabetes mandates a need for more effective strategies to manage the healing of complicated wounds. Maggot debridement therapy (MDT) is one alternative utilized with successful results. Observations have indicated that maggots have the ability to debride wound beds, provide anti-microbial activity and also stimulate wound healing in diabetic patients. None of the patients refused MDT due to aversion of this treatment modality and the majority of patients had minimal discomfort. In 17 of 23 patients with multiple co-morbidities, the treatment of their complex diabetic wounds by MDT resulted in improvement or cure. Maggot debridement therapy is an effective treatment of diabetic wounds.

Introduction

Patients with diabetes have difficulty healing wounds. This is especially true in the elderly whose numbers are increasing, resulting in rising cost for the delivery of health care. The annual cost to manage these wounds exceeds 20 billion dollars,¹ with a loss of over two million work days.² The diabetic foot ulcer in particular is more difficult to treat, costing between \$7,000 to \$10,000 per ulcer. Many of these ulcers may ultimately require amputation of a limb, where the cost may be as high as \$65,000 per person.³

There are numerous dressings to choose from, with costly new products coming to the market on a monthly basis, all claiming to improve outcomes. Maggot Debridement Therapy (MDT) has been infrequently used in the last 60 years due to improved dressings, new surgical techniques, and the surge of new antibiotics to treat non-healing wounds when they become infected.⁴ Medical-grade maggots became commercially available in 2004,⁵ and today there is a resurgence of interest in MDT with 12 laboratories in 20 countries dispensing them at low cost.⁶ They are approved for debridement of wounds with necrotic tissue, including pressure ulcers, venous ulcers, neuropathic foot ulcers, and non-healing traumatic or post-surgical wounds.⁷ A prospective, randomized study⁸ of patients with wounds comparing MDT to conventional therapy demonstrated the efficacy of MDT in debriding wounds, but there was no difference in the rate of healing. However, uncontrolled diabetics were excluded from the study. Furthermore, as there are no healthcare facilities using this treatment modality in the State of Hawai'i, the authors felt that a report of a case series of patients treated locally in Hawai'i with MDT, might be an impetus for further study and usage in this State.

Methods

Patients with diabetic wounds were evaluated for MDT and written consent for treatment was obtained. The maggots (*Lucilia sericata*) were obtained from Monarch Labs in Long Beach, California for \$98.00 per vial plus shipping. Each vial contained 250-500 maggots that were viable long enough for two MDT treatments. The skin was prepped with Cavilon–No Sting barrier film wipes and then Mastisol was applied to increase the adherence of DuoDERM to

the skin. Approximately 40-50 maggots were carefully inserted into the wound bed with a sterile Q-tip and gauze moistened with saline was applied on top of the maggots. The mesh, supplied by Monarch Labs, was then glued to the DuoDERM with rubber cement, forming a mesh “cage,” which confined the maggots to the wound bed (Figure 1). A bulky dressing was applied over the wound.

The patients and family members were advised not to disturb the dressing and warned that they would see increased drainage. The patients were then scheduled for follow-up appointments 48 hours later if they were out-patients, or treated in their hospital room 48 hours later if they were in-patients. After 48 hours the wound mesh was removed, and the maggots were then extracted from the wound with wall suction (Figure 1). If the wound was not completely debrided, maggots were reinserted and the wound covered again with mesh. This cycle continued until full debridement was attained.

Twelve of the 23 patients who began MDT as in-patients, were continued on MDT as out-patients. The other eleven patients were all begun on MDT as out-patients. All of the patients had diabetes in addition to multiple other co-morbidities, with 13 of the patients having a hemoglobin A1c > 10 (range 6.1 to 17.3, mean of 10.2). These diabetic patients had the most challenging wounds for debridement often times due to compromised vascularity, not amenable to sharp debridement. Five patients were on chronic hemodialysis with end-stage renal disease (ESRD). Eleven of the 23 patients' wounds had extended to the bone with underlying osteomyelitis.

Successful therapy was defined as full-debridement of the wound bed with enhanced granulation tissue formation with or without full closure of the wound. Often, MDT was followed by the application of negative-pressure wound dressings once satisfactory debridement was obtained. This encouraged the rapid formation of granulation tissue. Contraindications to MDT were open wounds in large body cavities and wounds in close proximity to large blood vessels. The team avoided MDT in patients allergic to eggs, soybeans or fly larvae. Coagulopathy was not a contra-indication but such patients were monitored closely since increased bleeding is common during therapy.

Results

The team began MDT in the fall of 2009 in a diabetic patient with a non-healing right hallux amputation. The wound would not close due to multiple co-morbidities (end-stage renal disease, diabetes, and heart disease). A negative-pressure wound dressing led to necrosis of his toes due to insufficient arterial flow. He adamantly refused a below-the-knee amputation. Previous studies^{9,10} have demonstrated fewer amputations using MDT when compared to conventional therapy. So, MDT was employed to assist in wound debridement and closure of the wound. Subtotal granulation occurred within one month, although devitalized bone still extruded from the wound. After three further months of MDT, complete debridement of exposed bone was obtained (Figure 1).

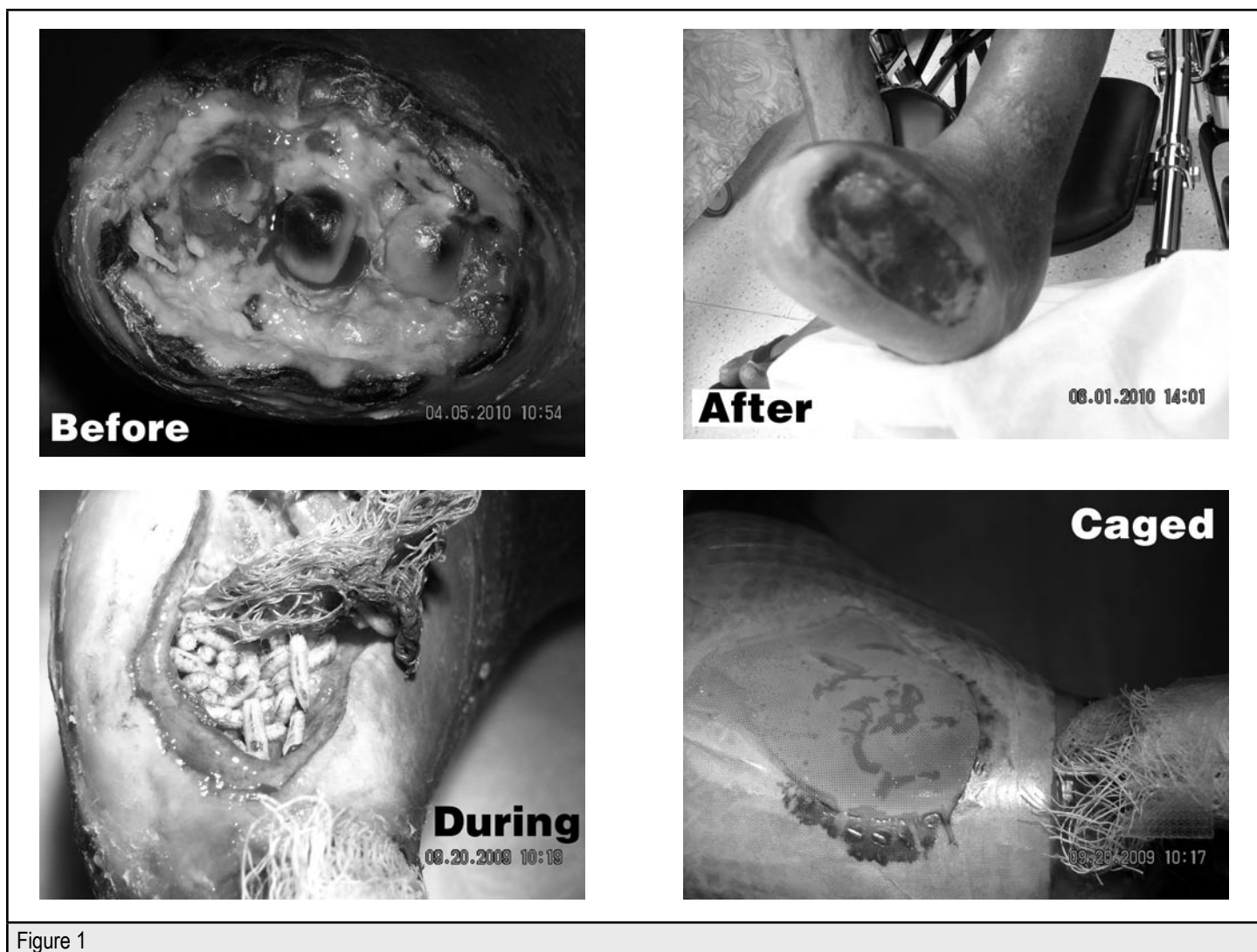


Figure 1

Over the past nine months the team has treated 23 diabetic patients with MDT. Clinical outcomes are displayed in Table 1. In 17 of 23 patients, successful outcomes were achieved by MDT. These 17 patients exhibited complete debridement with the formation of robust granulation tissue within their wounds. In fact, 6 of these patients formed granulation tissue over exposed tendons, avoiding tendon excision. While MDT may not completely close patients' wounds, partial closure of wounds was obtained in all of the successfully treated patients. For example, one patient with severe lymphedema had been treated since 2006 without any perceptible closure of his venous stasis ulcers. In 10 days, 75% closure of his ulcers was achieved by MDT. Two of the successfully treated patients required a skin graft to achieve full closure, and several others demonstrated further closure of their wounds with negative-pressure dressings. One patient with a large eschar over a below-knee amputation site demonstrated successful debridement of the eschar by MDT but initially did not exhibit granulation in the wound bed. After 30 days, MDT was discontinued and a negative-pressure dressing was applied. After one week further deterioration of the wound bed was observed thought to be due to impaired arterial flow to the extremity. Wet-to-dry dressings were instituted and successful closure of the

wound was obtained. Another remarkable feature observed during the treatment of diabetic patients with peripheral neuropathy was the return of normal sensation after several MDT treatments.

Six of 23 patients did not significantly benefit from MDT. Three patients who had osteomyelitis of the bones of their feet did not benefit from MDT due to narrow openings of their wounds (i.e., <1cm). Robust granulation tissue formation induced by MDT led to closure of their wounds before the maggots were able to reach the necrotic bone for debridement. In patients that had sufficient exposure of bone, therapy was successful with an apparent halt of bony destruction. A fourth patient had a deep venous stasis ulcer with documented leukocytoclastic vasculitis. The maggots ruptured a vein in her leg causing bleeding which necessitated early discontinuation of the MDT. She was not on anticoagulants. A fifth patient, severely debilitated from a coronary artery bypass graft, congestive heart failure, a cerebral vascular accident, and thrombocytopenia, was anti-coagulated with heparin. The maggots that were placed in his foot ulcer caused excessive bleeding. In a sixth patient who was status-post surgical debridement of a wound, excessive inflammatory reaction at the margins of the wound necessitated discontinuation of MDT. A negative-pressure dressing resulted in enlargement of

Table 1. Results of MDT						
Age	Sex	Wound	Co-Morbidities	Hgb. A1c	Length of MDT	Outcomes
66	M	R foot with OM	ESRD, DM, HD, PAD, OB	6.5	60 days	Successful
78	M	L foot	CABG, CHF, DM, CVA, OB, CRF	7.7	14 days	Unsuccessful - Excessive bleeding
56	F	R foot with OM	DM, OB	13.5	10 days	Successful
38	M	R foot with OM	DM, OB, CHF	11.9	2 days	Unsuccessful -Area closed in one treatment
57	M	R foot with OM	DA, DM, CVA, HD, S, CRF, CHF	11.9	11 days	Successful
61	M	R foot with OM	DM, ESRD, HD, CVA, CHF	10.5	15 days	Successful
78	M	BVSU	DM, LE, OB, COPD, CHF, CRF, HD	6.2	10 days	Successful- Three of four ulcers healed
72	F	R foot with OM	CRF, DM, HD	12.2	2 days	Unsuccessful -Area closed in one treatment
61	M	R BKA hematoma	DM, HD, CHF, CRF	8.1	30 days	Successful with delayed response
57	M	R foot	DM, HD, S, ETOH	12.8	10 days	Successful
51	M	R foot	DM, CRF	15.6	4 days	Successful
60	F	R foot with OM	DM, HD, OB, PAD	10.6	10 days	Successful
45	F	L Calf Ulcer	DM, OB, CRF	8.1	1 days	Unsuccessful -Ruptured vein
41	M	R foot with OM	DM, CRF, HD	17.3	12 days	Successful
46	F	L foot	DM, OB, CRF	11.5	4 days	Successful
60	F	R Calf	DM, OB	10.6	6 days	Unsuccessful due to pyoderma gangrenosum
56	F	R foot	DM	12.0	14 days	Successful
49	M	L foot	DM, OB, HD	9.4	10 days	Successful
56	F	L foot	DM, HD	6.2	8 days	Successful
54	M	R Hallux with OM	DM	13.6	8 days	Successful
60	F	L Hallux with OM	DM, ESRD, Stroke, PD	6.1	4 days	Unsuccessful -insufficient opening to dead tissue
58	M	L foot with OM	DM, HD, ESRD	6.3	4 days	Successful
43	F	L foot	DM, HD, OB, ESRD	6.2	6 days	Successful

OM – osteomyelitis; DM – diabetes mellitus; HD – heart disease; OB – obesity; PAD – peripheral arterial disease; ETOH – ethanol abuse; CHF – congestive heart disease; CRF – chronic renal failure; ESRD – end stage renal disease; CVA – cerebral vascular accident; CABG – coronary arterial bypass graft; S – smoker; LE – lymphedema, VSU – venous stasis ulcers, DA – drug addiction, COPD – chronic obstructive pulmonary disease, BKA – below knee amputation.

the wound, which the team later realized was due to pathology, as she was then diagnosed as having pyoderma gangrenosum.

In 60% of diabetic patients treated with MDT, erythema developed in normal skin surrounding the wound. The inflammatory reaction disappeared within 24-48 hours following temporary interruption of MDT, which was thereafter resumed without a resumption of the exuberant inflammatory reaction. None of the patients discontinued MDT due to an aversion of having maggots placed in their wounds. All of the patients were agreeable to the therapy and most were enthusiastic about this treatment option. Several of the patients complained of discomfort requiring analgesics. This has been previously reported in patients treated with MDT compared to conventional therapy.⁸ The patients that experienced pain had exposed bone and described the pain as a dull aching sensation that was adequately managed with oral analgesics. One patient temporarily interrupted therapy due to discomfort, but then resumed treatment a short time later without difficulty. Some patients did complain of a “creepy crawling” sensation in their wounds. One patient had maggots escape after getting the dressing wet. A few of the health care professionals were squeamish about assisting in the application and removal of the maggots.

Discussion

Wound debridement, originally thought to be a mechanical effect of the maggots,¹¹ has been shown to be due to three proteolytic enzyme classes that were identified in the maggot excretions.¹² Maggot excretions have an inhibitory effect on both Gram-positive and Gram-negative bacteria including methicillin-resistant *Staphylococcus aureus*, methicillin-sensitive *S. aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*.¹³ The ammonia excreted by maggots is believed to alter the pH of the wound, which inhibits bacterial growth.¹⁴ In 2001 a group of investigators examined the viability of *E. coli* in the gut of the maggot *Lucilia sericata* and found 67% of the proximal alimentary canal heavily infected. However, in the hindgut there was only 18% viable bacteria, demonstrating the bactericidal effect of maggot gastrointestinal secretions.¹⁵

There have been several studies attempting to identify how the maggots increase granulation in the wound bed. A study conducted in 2006 demonstrated an increased migration (but not proliferation) of the fibroblasts which was attributed to the action of serine and metallo-proteinases.¹⁶ Another study found high levels of gamma-interferon and interleukin-10 in the excretions of maggots that were thought to increase granulation tissue formation.¹⁷

The literature recommends not using maggots in a dry wound bed since they require a moist wound to survive.⁴ The team employed MDT successfully in dry wounds since the maggots create their own moist environment. It is important to advise patients of increased drainage from their wounds while receiving MDT since several of the patients verbalized fear that their condition was worsening when they observed increased drainage. MDT was a preferred method for patients who were not operative candidates due to their underlying vasculopathy. MDT is selective as maggots consume only necrotic tissue, leaving viable tissue intact. Patients needed reassurance that their wounds were not worsening when an exuberant inflammatory response surrounded their wounds. This disappeared in the majority of the patients in 24 to 48 hours, following temporary interruption of MDT. The patient with pyoderma gangrenosum experienced continued inflammation for 96 hours, which was likely due to pathology.

Conclusions

Maggots are able to debride diabetic wounds and stimulate wound healing. This study demonstrates that MDT is an effective strategy for the treatment of complex, diabetic wounds. Furthermore, the authors have shown that MDT works in dry, gangrenous wounds as well. Patient acceptance of, and satisfaction with, MDT was excellent. The majority of the patients tolerated MDT well with only a few experiencing pain that was adequately controlled with oral analgesics.

In 2004, the Food and Drug Administration approved medical-grade maggots for the treatment of chronic wounds.⁷ At least one randomized trial⁸ supports its use compared to conventional therapy. However this trial excluded uncontrolled diabetics. Since many patients with limb ulcers in Hawai'i have uncontrolled diabetes, the current study focused on this group, where the authors found MDT to be effective treatment.

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Atypical Presentations of Methemoglobinemia from Benzocaine Spray

Ekamol Tantisattamo MD; Nuntra Suwantararat MD; Joseph R. Vierra MD; and Samuel J. Evans MD

Abstract

Widely used for local anesthesia, especially prior to endoscopic procedures, benzocaine spray is one of the most common causes of iatrogenic methemoglobinemia. The authors report an atypical case of methemoglobinemia in a woman presenting with pale skin and severe hypoxemia, after a delayed repeat exposure to benzocaine spray. Early recognition and prompt management of methemoglobinemia is needed in order to lessen morbidity and mortality from this entity.

Case Report

A 59-year-old German woman underwent surgery for rectal prolapse. Routine general anesthesia was performed with sevoflurane, propofol, and vecuronium. Postoperatively, a nasogastric tube was placed for stomach decompression. On postoperative day one, the patient received 2-3 sprays of 20% benzocaine spray (Hurricane) to relieve sore throat due to irritation from the nasogastric tube. On postoperative day 4, the patient still complained of sore throat, and received 2-3 sprays of benzocaine, another 2-3 sprays was administered two hours later. She then immediately developed lightheadedness, chest tightness, difficulty breathing, and nausea. On physical examination, she was hypertensive and tachypneic; blood pressure was 160/60 mmHg, respiratory rate was 25 breaths per minute. She was not tachycardic. Cardiovascular, respiratory, and abdominal exams were all normal. However, her skin color and conjunctivae were pale and white like “a sheet.” The pulse oxygen saturation (SpO_2) was 74% on room air, and failed to improve with oxygen administered at 15 liters per minute via non-rebreather mask.

Laboratory and imaging studies including CBC, lactic acid level, chest X-ray, chest and abdominal CT scans were all within normal limits. An arterial blood gas showed a pH of 7.51, PaCO_2 of 34 mmHg, PaO_2 of 510 mmHg, HCO_3 of 26 mmol/L, and SaO_2 of 100% (FiO_2 100%) with dark-chocolate blood color noted. The patient was treated with intravenous methylene blue 50 mg. Her signs and symptoms resolved and SpO_2 returned to 97% on room air within 10 minutes after methylene blue treatment. Two hours later the completed methemoglobin measurement of 37%, confirmed the diagnosis of methemoglobinemia.

Discussion

Methemoglobinemia is a rare emergency condition divided into 2 categories: hereditary and acquired. Medications such as aniline, benzocaine, dapsone, nitrate, primaquin, and sulfonamides cause acquired methemoglobinemia by directly or indirectly altering ferrous ion in hemoglobin to become ferric ion.^{1,2} Benzocaine spray is the most common topical anesthesia which has been reported to be associated with methemoglobinemia.³ It is most often used prior to procedures such as endotracheal intubation, upper gastrointestinal endoscopy, and transesophageal echocardiography. Methemoglobinemia caused by other forms of topical benzocaine such as topical benzocaine 7.5% gel, 10% benzocaine ointment, and 20% benzocaine cream have been reported.⁴⁻⁶ The mechanism of benzocaine-induced methemoglobinemia is unclear but possibly related to an indirect

oxidant effect. Benzocaine interacts with oxygen and produces oxygen free radicals, oxidizing hemoglobin into methemoglobin.⁷ The classic findings of methemoglobinemia are a discrepancy between SpO_2 and SaO_2 , pulse oximetry desaturation which fails to improve with oxygen treatment, chocolate-colored blood, and cyanosis. Saturation gap ($\text{SaO}_2 - \text{SpO}_2$) is usually more than 5%.⁸ Limitations of traditional pulse oximetry, which can detect only 2 wave lengths of ultraviolet light: 660 and 960 nm, leads to an unreliable measure of oxygen saturation. As a result, co-oximetry detecting multiple ultraviolet wavelengths and all four types of hemoglobin should be used to measure an arterial blood gas and confirm the diagnosis of methemoglobinemia.⁸

Symptoms and signs of methemoglobinemia depend on methemoglobin concentration and range from mild symptoms such as headaches to coma and death.⁹ However, methemoglobin is measured as a percent of total hemoglobin, and symptoms may not necessarily correlate with concentration. Anemic patients, who have a lower oxygen-carrying capacity, may develop more severe symptoms.⁹ Cyanosis is a typical presentation of methemoglobinemia especially when methemoglobin concentration is up to 1.5 – 3.0 g/dL (methemoglobin 10 – 20 % in normal adult with the baseline Hb of 15 g/dL).⁹ Guay et al reported that of 152 adult patients with elevated methemoglobin level of 5% or greater, 66% presented with cyanosis. In pediatric patients with an elevated methemoglobin level of 12.6% or greater, the majority of patients also presented with cyanosis (51%), but the symptom of “pale skin” was noted in 21%.¹⁰ The presenting sign of pale skin should not be overlooked in children suspected of having methemoglobinemia.

Cyanosis results from increased deoxyhemoglobin or increased hemoglobin derivatives like methemoglobin. In methemoglobinemia, an elevated methemoglobin level causes cyanosis when reaching 25% deoxyhemoglobin without anemia. However, in producing cyanosis, the absolute quantity of deoxyhemoglobin is more important than the relative quantity of deoxyhemoglobin. Thus in patients with anemia there may be a discrepancy; the absolute amount of the deoxyhemoglobin may be low even though the deoxyhemoglobin may be large in relation to the total hemoglobin. As a result, patients with anemia may not have cyanosis or even have marked arterial desaturation. In addition, there are three factors determining the degree of cyanosis: the color of the skin pigment, the thickness of the skin, and the skin capillary state. Our patient had a methemoglobin level of 37% (3.63 g/dL with a hemoglobin of 9.8 g/dL). She should have had cyanosis more than pallor. The reason her skin was pale may be due to, (1) anemia with a hemoglobin of 9.8 g/dL, (2) white skin pigmentation and, (3) systemic vasoconstriction from sympathetic stimulation caused by the generalized hypoxemia secondary to methemoglobinemia.¹¹

In general, benzocaine-induced methemoglobinemia develops within 20 to 60 minutes and possibly up to 2 hours after exposure;² however, it could occur after re-exposure to a second dose of benzocaine spray up to 4 days after the first dose.¹² The maximum safe dosage of benzocaine is unknown, and it is also unknown whether

benzocaine-induced methemoglobinemia is idiosyncratic or dose dependent. Our patient developed methemoglobinemia after the third exposure to benzocaine spray. Methemoglobinemia in our patient may have been due to increase in the frequency and cumulative dose of benzocaine administration between the second and the third dose (duration was 2 hours apart). Moreover, our patient has known risks for methemoglobinemia including anemia, history of smoking, and oropharyngeal inflammation from the nasogastric tube.⁸ Thus her methemoglobinemia after delayed reexposure to doses of benzocaine spray was likely multifactorial in etiology.

A high index of suspicion, prompt diagnosis, and early treatment are very crucial to avoid prolonged methemoglobinemia. The severity of methemoglobinemia depends on the level of methemoglobin, and a level more than 70% could be fatal.⁹ The treatment of choice for acquired methemoglobinemia is 1 to 2 mg/kg of intravenous methylene blue over 5 minutes, and repeat 1 mg/kg if the patient still has symptoms after 20 minutes.^{8,12} Ascorbic acid is another treatment option for the glucose-6-phosphate dehydrogenase (G-6-PD) deficiency patient but its onset of action is slow.¹³ Other alternative treatments include: cytochrome P-450 inhibitors such as N-acetylcysteine and cimetidine, but the evidence for these agents is limited and further research is required.⁹ In addition, monitoring symptoms and signs of methemoglobinemia after treatment with methylene blue is necessary because rebound methemoglobinemia may occur up to 18 hours after treatment.¹⁰

Conclusion

Methemoglobinemia is a rare but potentially lethal condition if not promptly recognized and treated. Benzocaine topical spray is the most common cause of iatrogenic methemoglobinemia. Cyanosis in combination with SpO₂ - SaO₂ discrepancy as well as dark-chocolate blood is a classic clinical presentation of methemoglobinemia. However, severe pallor may be present in the patient with underlying anemia. Symptoms and signs of methemoglobinemia may not occur at the first time of benzocaine application, and reexposure to benzocaine may result in an excessive dosage and precipitating methemoglobinemia.

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Developing Communication Skills for Leading Family Meetings

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Introduction

Despite the importance of communication skills with families and its association with better clinical outcomes, training of medical students, residents, and fellows about communication skills in family meeting settings has not been well established. In a study to assess neonatology fellow training in guiding family decision making, more than 40% of fellows reported no training in communication skills and feedback for fellow-led family meetings, and 93% of fellows reported they felt that training in this area should be improved.¹

The importance of communication with patients and families has been well documented,²⁻⁵ but less attention has been paid to communication with families. Communicating with clinicians is extremely important to family members. Families rate the communication skills of clinicians as having equal or higher importance than clinical skills.⁶

Involving the family in a patient's care can lead to improved outcomes in patient care. For example, Tsouna-Hadjis et al reported that patients with moderate/severe stroke and high levels of social support attained a significantly better and progressively improving functional status than those with less support. The authors concluded that high levels of family support (both instrumental and emotional), are associated with progressive improvement of functional status.⁷ Also, in settings where patients may lack the capacity to make decisions about their own health care, family members can assist in providing history, communicating treatment preferences, and assisting in discharge planning.

An intervention in the intensive care unit (ICU) setting to increase communication with the family by requiring a family conference within 72 hours of admission to the ICU was shown to reduce the length of stay for patients who ultimately die in the hospital. This study suggests that increased communication with families can also decrease the prolongation of the dying process.⁸

The patient, family members, and medical team can all be present in a family meeting at the same time to facilitate the establishment of goals of care by sharing information, including prognosis and treatment options necessary for decision making. The physician and medical team can assess the understanding and goals of the patient and family, and identify conflicts that might exist within them. To lead successful family meetings, physicians need to develop skills in establishing rapport, describing the clinical situation, and explaining prognosis, risks, and benefits of treatments by using clinical judgment and skill in group facilitation, providing emotional support, and helping the family make medical care decisions. In addition, physicians must be able to tolerate and manage conflict and be comfortable with expression of emotions by family members.

Communication skills training in leading family meetings at JABSOM

In the University of Hawai'i Geriatric Medicine Fellowship Program, clinical lectures about communication skills and family meetings have been established. Geriatric Medicine fellows are evaluated on their communication skills by their faculty supervisors during their clinical rotations. Fellows also have opportunities to practice their communication skills with standardized patients. Encounters with standardized patients are videotaped and reviewed with faculty members.

However, there has been no similar structured communication skills training of fellow-led family meetings. The comfort level with leading family meetings varies from fellow to fellow, depending on each fellow's interest and prior experiences. The chance of having fellow-led family meetings attended by faculty members and other staff members can be quite variable. Furthermore, feedback from the patient, their family and other healthcare staff is rarely given to the fellows.

Plans for future development of communication skills in family meetings at JABSOM

In developing communication skills training for family meetings in the University of Hawai'i Geriatric Medicine Fellowship Program, three issues are addressed:

1. Who will be involved?
2. What teaching methods will be utilized?
3. Evaluation of the effectiveness of this training?

Who is going to be involved?

- Geriatric Medicine fellows and faculty members
- Patients and patients' family
- Medical staff involved in the family meetings

What kind of teaching methods should be utilized?

- Fellows will be taught a faculty-led seminar on essential skills needed to conduct successful family meetings. As part of this seminar, a case study and role play exercise will provide the fellows with the opportunity to actively apply and practice what they are learning. Close behavioral observation of each other will help the learners identify their strengths and weaknesses.
- During clinical rotations, the fellows will attend family meetings led by their supervising faculty members. Fellows will be able to observe and learn from experienced faculty with expertise in the

area. These faculty-led family meetings will also help to broaden the fellows' perspective and improve their understanding of the strategies and techniques for addressing communication challenges; for example, conflict and transitions of care.

- Fellows will become better prepared to lead family meetings through these experiences.

Evaluation of the effectiveness of this training

- The Geriatric Medicine fellows will provide feedback regarding the faculty-led seminar, using quantitative pre- and post-tests of attitudes, skills and knowledge. The fellows will be surveyed to assess their comfort level and confidence level before and after the training.
- Following this training, each fellow will be required to conduct at least 5 family meetings attended by their supervising faculty on designated rotations. A written feedback checklist will be created, so that each fellow will receive written feedback from their supervising faculty member, the patient, the patient's family, and other medical team members in attendance. There are several standardized feedback forms which could be used or modified, such as the patient perception scale (see appendix), already in use in the fellowship to gather feedback about other types of patient encounters. The feedback will be provided to the fellows in a timely manner, at the end of the family meeting.

Summary

Good clinician-family communication is essential for the provision of high-quality patient care. Families rate the communication skills of clinicians as critical clinical skills. However, there has been no structured training of fellow communication skills while leading family meetings in the University of Hawai'i Geriatric Medicine Fellowship Program. Effective training to develop communication skills with families will better prepare Geriatric Medicine fellows for this important task, and ultimately improve the quality of care they provide to these patients and patients' families.

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APPENDIX

PATIENT PERCEPTION SCALE

Please note that the only purpose of this form is to evaluate and provide feedback to the Geriatric Medicine fellows who are in training. The information will be given to the fellow in a summarized form (along with feedback from other patients, family medicine and staff). This form will **NOT** be shown to the fellows, so please feel free to be very honest in your evaluation.

Fellow's Name _____ Year of Training: F1 F2

Patient's Initials: _____ Date of Evaluation: _____

Setting (circle site): 1-Hospital 2-Clinic 3-Nursing Home/CFA 4-Home Visit

Person completing the form (please check 1):

____ Patient
____ Family Member (Relationship to patient: _____)
____ Staff, specify (eg. RN, MSW, etc) _____

HOW WAS THE GERIATRICS FELLOW DOCTOR YOU JUST SAW AT THE FOLLOWING:
(check one blank for each item)

	POOR	FAIR	GOOD	VERY GOOD	EXCELLENT
1. Did the doctor greet you warmly?	_____	_____	_____	_____	_____
2. Was the doctor friendly?	_____	_____	_____	_____	_____
3. Did the doctor treat you with respect?	_____	_____	_____	_____	_____
4. Did the doctor listen carefully and not interrupt you while you were talking?	_____	_____	_____	_____	_____
5. Did the doctor show interest in you as a person?	_____	_____	_____	_____	_____
6. Did the doctor encourage you to ask questions?	_____	_____	_____	_____	_____
7. Did the doctor answer your questions clearly?	_____	_____	_____	_____	_____
8. Did you understand what the doctor said when explaining your problems?	_____	_____	_____	_____	_____
9. Did the doctor understand what you are experiencing?	_____	_____	_____	_____	_____
10. Did the doctor give you a sense of hope and encouragement?	_____	_____	_____	_____	_____

COMMENTS: _____



❖ NEVER LET YOUR DAILY CALORIC INTAKE EXCEED YOUR WHITE BLOOD COUNT.

Hannah Gardener, epidemiologist at the University of Miami Miller School of Medicine, studied consumption of diet sodas by 2500 New Yorkers over a nine year period. Findings showed that those who consumed one or more diet drinks each day increased their risk of a severe vascular event, including stroke and heart attack by 61% compared with a similar population that eschewed such beverages. Researchers admit that one study is not sufficient to condemn diet drinks and Dr. Gardener said, "Stay tuned. I don't think anyone should change their behavior based on one study." Still, the summary line is: develop fat thighs and a big belly with associated risks by imbibing sugary daily sodas, or drink diet colas and up the chance of heart attack or stroke. Of course, there is the radical idea of merely drinking tap water.

❖ GEORGIE PORGIE KISSED THE GIRLS AND MADE THEM CRY.

Human papillomavirus (HPV) is a highly prevalent infection in men. Frequently the infected person has no signs nor symptoms but can spread the disease to a sexual partner. A research team at H. Lee Moffitt Cancer Center and Research Institute in Tampa, Florida, reporting in Lancet, studied a volunteer group of 4,000 men living in Brazil, Mexico and Florida beginning in 2005. Upon enrollment swabs were taken of the penis and genital area of each man which revealed that 50% were infected with at least one HPV type upon enrollment. Over the succeeding 28 months, the group acquired 1,572 new HPV infections. Male circumcision and use of condoms showed little protection against the disease. The virus is notorious for causing cervical cancer in women, and can hang on unnoticed for months or even years. The study is highly important for strengthening the case for vaccinating men and boys. It's especially important for the gay population with the threat of rectal cancer as well as venereal warts. At \$130 per shot (three for efficacy) no line is forming.

❖ SPILL A ROACH ASH ON YOUR SHIRT AND YOU HAVE A POT HOLE.

In the 2010 fall election California voters rejected Proposition 19, which would have legalized small amounts of marijuana for recreational use. The measure would have allowed local governments to regulate and tax the commercial production and sale of marijuana to adults. California has had a medical marijuana law in place for fourteen years, and a pre-election poll by Survey USA found that 48% of likely voters were in support of Proposition 19 and 41% were opposed. On election day the vote count was 54% against and 46% in favor. The Obama administration drug policy very nearly echoes the previous administration. White House spokesman Gil Kerlikowske stated that Californians recognize that legalizing marijuana will not make citizens healthier, will not solve the budget crisis and will not alter the drug wars in Mexico. The legalization issue is dead in California for the present, but it is sure to arise in another state in the near future.

❖ THE FOOD WAS OKAY, BUT THE PLACE LACKED ATMOSPHERE.

Researchers at NASA's Johnson Space Center are in the midst of a multi-years study of how the human heart reacts to weightlessness in prolonged space flight. Data presented at the annual meeting of the American College of Cardiology included findings that on trips lasting less than 30 days, 25 to 30% of astronauts have trouble maintaining blood pressure. When voyages last longer than one month, 80% have low blood pressure, develop symptoms like tunnel vision and may have cold sweats. Astronauts are likely to lose heart mass and develop what is called "Grinch Syndrome" (named after the Dr. Seuss character whose heart was two sizes too small). Blood volume decreases, arrhythmias are common, blood pressure becomes abnormally low and, fainting and dizziness are frequent. While on the space station, astronauts are advised to work out for two hours each day, usually on a treadmill or strapped on a bicycle, but exercise with a stationary rowing machine was ergonomically superior. Thirty minutes of rowing was equal to 90 minutes of cycling.

❖ MEDICINE IS AN HONORABLE PROFESSION EXCEPT WHEN IT ISN'T. PART I

In Chicago, Mark Weinberger, an otolaryngologist awaiting sentencing for healthcare fraud was ordered to pay \$13 million in a malpractice lawsuit. The award includes \$10 million in punitive damages to the estate of a deceased

woman. He negligently failed to diagnose a nasal cancer and performed unnecessary and damaging sinus surgery. She died despite vigorous therapy by a second surgeon who immediately recognized the cancer. The case was the first of 350 malpractice lawsuits against Weinberger. He is scheduled to be sentenced for his admitted guilt in 22 counts of healthcare fraud. He billed insurance companies for up to \$400,000 for surgeries which he did not perform. He had fled to northern Italy and was living in a tent when he was apprehended.

❖ MEDICINE IS AN HONORABLE PROFESSION EXCEPT WHEN IT ISN'T. PART II

In Portland, Oregon, neurosurgeon James Makker lost his surgical privileges at Providence Medical Center when it was discovered that he had the highest rate of spinal-fusion surgeries among 3,407 spinal surgeons who performed similar operations. Dr. Makker's rate was ten times the national average, and some of his patients had multiple fusions – one patient had seven spinal procedures! Another malpractice complaint against the doctor was recently filed, the ninth in the last seven years. Ugly enough, but there is more. Dr. Makker got his spinal implants through Omega Solutions of Fresno, California, a Physician Owned Distributorship (POD). This limited liability company (LLC) acts as a middleman between medical device makers and hospitals. Surgeons dictate to hospitals which devices to buy, so by offering physicians partnership in the POD they lock up the hospital's business allowing the surgeon to profit. The Office of the Inspector General of the Department of Health warned that PODs may violate anti-kickback laws, and the FBI is asking questions about Dr. Makker. The Oregon Board of Medical Examiners has opened its own investigation.

❖ BLACK DEATH IN A LAB COAT.

A type two diabetic, sixty year-old man who worked in a research lab went to an outpatient clinic with a three day history of fever, body aches, and cough. The clinic physician suspected an acute respiratory infection and referred the man to an emergency department (ED) for evaluation, but the patient chose to return home. Three days later he was brought by ambulance to a Chicago hospital ED with fever of 100.9 F, pulse of 106, respirations at 42 per minute, and blood pressure of 106/75. He was alert and responsive. Examination showed distant breath tones, abdominal distention, peripheral cyanosis, but no rash, jaundice, nor lymphadenopathy. Bacteria were noted in a peripheral blood smear. Chest x-ray revealed normal lung fields. Believing he was in congestive heart failure with infection, the physician prescribed diuretics and IV antibiotics. Twelve hours after admission the respiratory distress became critical, and he was intubated. He died within an hour. Resuscitation efforts failed. Culture revealed *Yersinia pestis* (*Pasteurella pestis* to us geezers) believed to be lab-generated plague. The last known laboratory-acquired plague infection was in 1959.

❖ IT MIGHT PRODUCE A FROZEN COCKTAIL.

A central Pennsylvania man was spotted stealing frozen shrimp in a super market. While he was stuffing his loot into his shorts he was apprehended by a security officer who suffered minor injuries. The icy-pants thief ran to the parking lot where he was caught by the security guard and a helpful bystander. No report was given about the fate of the frozen shrimp.

❖ IT WIGGLED AND RIGGLED AND TICKLED INSIDE HER.

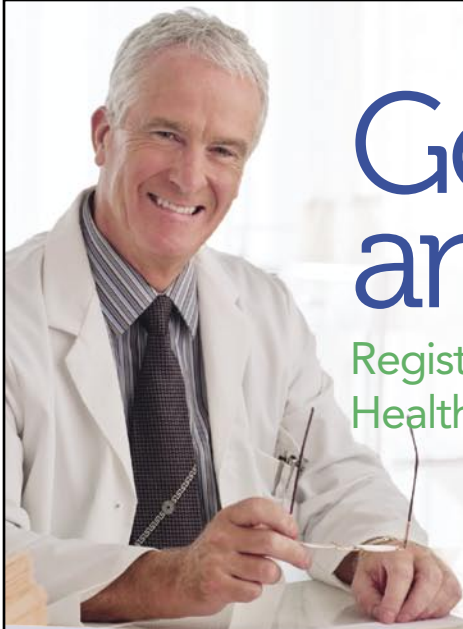
At Albert Einstein Medical Center in Philadelphia, a physician reported finding a cockroach in the transverse colon of a 52 year-old woman during a routine colonoscopy. Previously other tiny creatures, eg, ants, wasps, bees, had been reported, but this is the first reported cockroach. Still, as the physician noted, cockroaches are considered a delicacy in some countries. If it had been a standard humongous Maui cockroach it would have obstructed the bowel.

ADDENDA

- ❖ An Article in Archives of Internal Medicine found that one of every 100 patients goes to the emergency room following colonoscopy, most commonly for abdominal pain believed to be from trapped air.
- ❖ When you try bungee jumping take the change out of your pockets.
- ❖ Grown men do cry, but only when assembling furniture kits.
- ❖ Immortality is a long shot, I know, but hey, somebody has to be first.

ALOHA AND KEEP THE FAITH — rts■

(Editorial comment is strictly that of the writer.)



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