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INTRODUCTION

The COVID-19 pandemic has created unprecedented changes in how organizations plan for and deliver medical education and patient care. As a result of the pandemic, medical schools and healthcare delivery systems were forced to pivot quickly to find best practices to sustain or promote healthy outcomes for patients and provide productive educational opportunities for medical students. While the specifics of the coronavirus outbreak may have been unforeseen a year ago, the principles of pandemic planning and outbreak modeling have been present for decades. At the Penn State College of Medicine, University Park Regional campus, we have used a simulated outbreak as part of our core orientation for medical students to promote teamwork, critical thinking, and public health awareness while simultaneously familiarizing students with the geography, ethnography, and resources available in the local community.

DECISION-MAKING, PANDEMIC PLANNING AND CRITICAL THINKING

Historical models of decision-making focus on how people "should reason" to conform to accepted norms of rationality and utility.[2] Such dichotomous, binary reasoning has shifted towards a revised heuristic-analytic theory of reasoning.[10] This theory proposes that judgment and reasoning are facilitated by individual mental models (singularity) that couple with heuristic processes to contextualize situations to meet immediate goals (relevance). In the context of applying decision-making to pandemic planning and crisis response, the National Incident Management System (NIMS) was developed. The cornerstone of NIMS is the Incident Command System (ICS), which promotes procedural interoperability across all levels of incident response.[3] Despite this framework, nuanced emergency situations inevitably dictate that not all exigencies can be adequately addressed. Health systems and individual providers find themselves developing and deploying improvised, moment-to-moment methodologies to address complex and multidimensional crisis situations.[4] A specific example of this in the current COVID pandemic was the early struggle that a majority of health systems faced to ensure adequate personal protective equipment for providers and staff. Recent studies evaluating hospital preparedness and adherence to NIMS principles suggest that medical facilities lack a gold standard for measuring and evaluating readiness, particularly with regard to command, communications and information management.[5] Steady increases in emerging threats, such as the recent COVID-19 outbreak, provide ample motivation to develop new methods of preparing the next generation of crisis responders.[7]

At the Pennsylvania State University, faculty use scenario-based activities in the form of an analytic decision game (ADG) as pedagogy for engaging, educating, and training medical students as critical thinkers. The ADG is an adapted tactical game that creates a virtual crisis requiring participants to engage in scenario management as role-players. ADG scenarios vary by subject and audience and are readily adaptable to a wide variety of crisis responses. For the past 3 years, students from the Penn State College of Medicine University Park Campus have participated in the ADG *EpiCentre* scenario. This scenario tests community preparation and resilience after a widespread and months-long epidemic. The *EpiCentre* construct was specifically selected to introduce students to the demographics and resource infrastructure of the local community, taking place in a rural setting matching the area surrounding the Penn State campus. *EpiCentre* commences with several, similar patient cases of a non-specific viral illness that escalate to a county-wide epidemic. During the facilitated exercise, students collaborate to address an ever-expanding set of community, security, and health-related issues, engaging in decision-making processes to manage the burgeoning crisis. The decision-making processes of the *EpiCentre* exercise are analogous to clinical reasoning skills students develop and employ as physicians.[6]

CRISIS RESPONSE AS AN INTRODUCTION TO CLINICAL REASONING—WHAT DOES COVID TEACH US?

Clinical reasoning is a complex process by which health care providers solicit and collect cues, process information, and assess available data to arrive at a diagnosis. This information is also used to plan and implement strategies to successfully treat the problem (diagnosis). The process loop continues with the evaluation of results in terms of patient outcomes and reflection on action to learn from the process and better inform future practice. To improve clinical reasoning

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processes, there is keen interest in examining how individuals make decisions under conditions that are high-stakes, time-constrained, and dynamic.

In the late 1960s, Daniel Kahneman, a psychologist/behavioral economist most well known for his work on the psychology of judgement and decision-making, teamed up with Amos Tversky, a cognitive and mathematical psychologist, to explore and establish a cognitive basis for common errors in decision-making. To investigate how humans make decisions, Tversky and Kahneman[8] outline 2 systems of intuitive reasoning and extensional reasoning. The former is quick, unstructured, and informal (using heuristic-enabled processes), while the latter takes time and effort and is structured and controlled. Jonathan Evans a well-known cognitive psychologist, developed the heuristic-analytic theory[9] that explains mismatches in reasoning due to cognitive bias. Heuristic-analytic theory proposes that 2 sequential cognitive processes are at work for any given reasoning task. These include 1) *heuristic* processes, which draw from prior experience and expectations to aid in the formulation of representative models, and 2) *analytic* processes, which draw on sense-making techniques to form judgments on these models. Heuristic-analytic theory was extended[10] to account for the inclusion of hypothetical thinking as a means to broaden the range of considerations beyond those represented by known facts. In 2004, Magda Osman integrated previously held distinctions between analytic and intuitive reasoning into a single-system model called dynamic graded continuum (DGC).[11] This framework represents an alternative model to dual-process theory. The DGC framework proposes that representative reasoning could be viewed as a continuum from implicit to explicit and automatic.

Recognition primed decision (RPD) and naturalistic decision making (NDM) are 2 other models that describe how experienced practitioners solve complex problems. In the RPD model, experience results in a cognitive catalog of possible actions and the typical course of action is the first one considered. RPD recognizes the value of intuition-enabled analysis in decision making, especially when applied by seasoned practitioners (particularly physicians, military personnel, and emergency responders) who often operate in high-stakes situations. Whereas intuition (honed through experience) can help recognize patterns and construct potential response strategies, this may not be appropriate in all situations. In the NDM framework,[14] cognitive task analysis encourages decision-makers to develop alternate options and conduct probability estimates to determine the best course of action. This raises the question of how best to train future practitioners (who lack experience) to construct intuitive strategies. One such method is through gaming and simulation.

The present COVID-19 pandemic, in particular, provides the opportunity to examine decision-making processes using the previously established ADG frameworks. Addressing asymmetric threats like COVID requires reasoning that is dynamic, adaptable, and tailorable to a wide range of possibilities. Clinical reasoning in complex medical cases[13] can also be viewed as a series of asymmetric threats. At both the individual level (caring for complex COVID patients) and the health systems level (creating an organized response to the COVID-19 pandemic), complex reasoning and critical thinking skills are essential.

INQUIRY-BASED MEDICAL EDUCATION

The Penn State College of Medicine has a long-standing scientifically and clinically rigorous educational tradition with deep foundations in scholarship and humanistic care. Penn State recently built on this experience to open a regional campus in University Park, PA. This novel program uses trans-disciplinary educational strategies to create a flexible and integrated program of study. Students learn in an environment that fosters interprofessional team skills, curiosity, and a commitment to the calling of Medicine. A number of guiding principles form the basis of this collaborative curriculum. Students are engaged from the first day of medical school to contribute in meaningful ways to the health of patients and populations while also working to improve the health system. Students are challenged to address the needs of the local community as a scaffold for transferring cognitive and clinical skills to a national and global context. The curriculum features community engagement; inter-professional, team-based care; advocacy and leadership to promote the health of patients and populations; experientially driven learning in biomedical science, clinical science, and health systems science; longitudinal learning relationships; flexible assessment; and a culture of respect and humanistic care.

Educational experiences are designed to emphasize interprofessional collaboration, critical reasoning, and systems thinking. To do this, the curriculum uses experiential learning and clinical immersion for students to integrate 4 core educational pillars: biomedical sciences, clinical sciences, health systems sciences, and health humanities. The design of the curriculum is based on the best evidence in the science of learning and anchored in a culture of continuous critical reflection, rigorous evaluation, adaptability, and innovation. The educational design embraces opportunities for interprofessional collaboration with educators from other disciplines, a process that gave rise to translating the Analytic Decision Game *EpiCentre* to medical education.

RED TEAMING AND THE ANALYTIC DECISION GAME (ADG)

The use of hypothetical thinking in problem-solving is not new. *Red Team Analysis*, a form of alternative analysis - has been in use by military planners since the Cold War.[15] In the 1960s, early military red teamers utilized game-theory techniques to evaluate strategic decisions. Red team analytics models the behavior of individuals or groups by emulating their thought processes in order to anticipate probable (adversary) actions. The Red Cell Analytics Lab (RCAL) on the campus of The Pennsylvania State University, has combined the tenets of red teaming with the ADG to analyze multiple scenario-based threats. COVID-19 adds a layer of urgency and importance to such work.

The Analytic Decision Game (ADG) was developed as a pedagogy to bridge theory and practice in collegiate classrooms by applying structured and unstructured analytic techniques to solve problems of security and risk (including natural and man-made crises).[16] The ADG combines the tenets of PBL and experiential learning with analytic techniques, allowing students to experience relevant academic content while simultaneously developing skills in problem-solving, critical thinking, communication, collaboration, and creativity.

EpiCentre: THE SCENARIO

For many of the medical students at the regional campus of the Penn State College of Medicine, *EpiCentre* was their introduction to rural America. The scenario is set in Centre County, where our Regional Campus is located. The *EpiCentre* simulation provides students with topographical county and community maps, a demographic study of the region, a countywide Strengths-Weaknesses-Opportunities-Threat (SWOT) analysis, and a 200-year oral history created from data collected from local resources in Centre County. The crisis response exercise was initially developed for Security and Risk Analysis students in the College of Information Sciences and Technology. After collaboration with Penn State Medical School faculty and recognition of the utility of exercise-based approaches and the parallels between analytic reasoning and clinical reasoning, the scenario was radically adapted for incoming medical students to create the *EpiCentre* ADG.

At the beginning of the exercise, 3 teams are formed corresponding to 3 communities within Centre County. Students take on leadership roles to guide their respective communities through the constantly evolving public health crisis. As the scenario progresses, it becomes obvious that identified issues cannot be fully resolved during the span of the exercise (a situation often found in the context of clinical decision making in real-life patient care). The time-constrained nature of the exercise forces students to prioritize and focus, the same as with real-life crises situations.

The *EpiCentre* scenario plays out in 4 parts:
Part-1: *Welcome to Centre County* - EpiCentre begins with having the teams get to know their respective communities. In this initial phase, students are put in the role of community leaders of 3 geographically and economically distinct communities. Students must identify available resources, assess any immediate threats to health and safety, conduct risk assessments, and identify high-risk populations.

Part-2: *Cough and Chills and Constipation, Oh My!* - Students are introduced to their "Patient Zero." In this second phase, students within each of the 3 communities interview several simulated patients who present with non-specific complaints. Students practice patient history taking skills and are asked to develop a rudimentary differential diagnosis. Because this potentially represents the first experience incoming students have with patient interviewing, they are provided with several "how-to" guides on history taking and construction of a differential diagnosis, both of which are foundational components of clinical decision making. Each team also has a senior medical student to help guide them as a near-peer educator, particularly with respect to the clinical decision-making process. Senior students were encouraged to ask helpful questions, help develop an initial problem list, and differential diagnosis supported by positive and negative findings. The entering students are then asked to submit their final formal clinical note with rationale for each differential diagnosis to the faculty for feedback. Standardized patients also provide real-time feedback regarding each student's data gathering and interpersonal communication skills.

Part-3: *Houston, We Have a Problem* - As the scenario progresses, students continue to see standardized patients with clustered presenting complaints at a higher frequency. They begin to realize that "something is not normal". Students from each community are encouraged to contact neighboring communities to determine patterns of disease presentation, marshal available resources and decide what to do. They are also asked to revisit their differential diagnosis when they receive new information (e.g. public health updates and news briefs) that is provided in a spontaneous and unpredictable manner during the simulation. Public health concepts, such as case identification, containment, mitigation, and contact tracing, are emphasized during this phase of the activity.

Part-4: *Power in Numbers* - The community teams are encouraged to work together to form a Health Care Coalition. Students continue to gather, interpret, and evaluate information so that they apply across the county. This larger group must create an immediate action plan based on CDC recommendations, map and track disease progression,

explore state and national level reporting systems, and develop a cooperative plan of action.

EpiCentre: A SHARED EDUCATIONAL MODEL FOR CRISIS RESPONSE

To date, there have been 3 iterations of the *EpiCentre* activity with arriving first-year medical students. After each, a comprehensive after-action review was conducted. Common findings suggest that most students found the introduction to established disaster management protocols from the Centers for Disease Control to be quite helpful. In addition, students appreciated the ability to practice different methods of leadership and collaboration. This is not something the students were expecting during their first week of medical school. Retrospectively, students also highlighted the value of *EpiCentre* in terms of day-to-day clinical reasoning and problem solving, as well as their understanding of different public health approaches in the context of the COVID-19 pandemic—an event that they did not see coming at the time of the initial exercise.

The value of the *EpiCentre* activity has come into additional focus for students during the COVID pandemic. As Penn State College of Medicine shifted to online coursework, all students (n=152) from the regional and main campus concurrently enrolled in a course on public health and underserved medicine entitled *Health Systems and Equity*. As part of the course, students discussed the disparate impact of the COVID pandemic on vulnerable populations. Students from the regional campus mentioned being comfortable with pandemic planning material while students from the main campus reported that this material was completely new for them. Other students from the regional campus used their *EpiCentre* experience to further expand their public health awareness and brainstorm solutions for healthcare delivery to vulnerable populations. Students from the regional campus felt well prepared to address the course learning objectives and outline the NIMS structure and function. This provides anecdotal evidence that *EpiCentre* was useful in helping students develop clinical reasoning skills while also providing a fundamental understanding of public health and pandemic preparedness.

CONCLUSION

The asymmetric nature of crisis, whether natural or man-made, requires thought processes and analytic strategies that are dynamic, adaptable, and applicable to a wide range of possibilities. The strength of the ADG lies in its inherent flexibility. Design features are tailored to specific desired learning outcomes. In the case of EpiCentre 2020, the design of the exercise focused on elements such as building cohesive teams, adult learning theory, COVID crisis planning, and COVID crisis response. Other elements, such as evidence-based reasoning, examining correlation versus causation, and practicing clinical reasoning skills were included. The activity emphasized principles of active adult learning by linking the evolving pandemic with the creation of a tangible COVID-response plan for the local community. The time-constrained nature of this year's exercise, coupled with real-life constraints imposed by the pandemic did not allow for the typical post-exercise after-action review. This review allows exercise to highlight areas that may not have been obvious and allows participants to ask specific questions about the exercise design, sequence, or content.

The analytic decision game is an interesting pedagogical strategy designed to promote critical thinking in the context of developing clinical reasoning skills. The *EpiCentre* ADG at The Penn State College of Medicine has been utilized to promote the development of interprofessional team skills, curiosity, and problem-solving skills in the specific context of disaster preparedness. The COVID pandemic emphasizes the real-world applicability of a thoughtfully created clinically relevant analytic decision game. The utility of this particular ADG was made particularly evident in the context of the COVID-19 pandemic as a tool to help students gain greater insights on the nature and effects of the COVID disease on individuals and on society while simultaneously using this information to create a specific public health plan to benefit the local community.

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