ORIGINAL RESEARCH

The educational benefit of integrating genomic principles into an evolving simulation scenario

Leighsa Sharoff*[1,2]

[1] School of Nursing, Hunter College, United States
[2] School of Nursing, City University of New York, United States

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ABSTRACT

Background and objective: Simulation-supported scenarios were infused with genomic principles to increase undergraduate nursing students' knowledge of the disease of Cystic Fibrosis (CF) and its genomic implications. The primary aim explored how a genetic component in an evolving CF simulation scenario (at 3 weeks old, 6 years old, 26 years old and 47 years old) could enhance pre-licensure baccalaureate nursing students' self-perceived ability to integrate genomics into their nursing knowledge base. A second aim explored students' confidence in their ability to participate in patient care.
Methods: Three assessment surveys gleaned data from a total of six intervention groups (n = 103): (1) identical nine-item pre/post simulation learner survey of CF knowledge gleaned students' basic genomic knowledge; (2) five-item post-simulation, self-perception of learner knowledge survey gathered students' self-perception of their CF genomic; and (3) one open-ended qualitative question that asked participants to share if they "felt that this scenario enhanced their overall ability to integrate genomics into their knowledge base of nursing and nursing care." Six control groups (n = 46) did not receive the CF scenarios but completed the nine multiple choice survey once.
Results: All of the six collective intervention groups total post-simulation knowledge averages improved or remained the same as pre-simulation CF knowledge. Comparatively, all total post-simulation CF knowledge averages were considerably higher than the control groups CF knowledge average. Participants' overall theoretical knowledge of CF post simulation was significantly higher than the control group. All five learner CF knowledge survey items had the majority of participants agreeing their genomic knowledge improved post simulation. Three major themes, with seven sub-themes, emerged from the rich qualitative data.
Conclusions: Simulation solidifies comprehension of genomics application of knowledge from didactic theory to practice experiences, providing a reliable and valid pedagogical educational strategy, not only for cognitive, psychomotor and affective learning, but also for genomic proficiency. Integrating an evolving CF simulation scenario can facilitate concepts of genomics, nursing care, and patient advocacy while enhancing students' confidence and comfort level.

Key Words: Simulation, Cystic fibrosis, Evolving scenario, Pre-licensure, Education, Genomics

1. INTRODUCTION

Genomically-based personalized medical management care has transformed not only how a patient receives their healthcare but how the healthcare provider is educated. Nurses have a fundamental responsibility to have the knowledge and confidence to advocate and communicate effectively about genomics and precision medicine.[1] Academe must remain at the forefront during this genomic era to adequately educate the next generation of professionals. Given the constraints of a demanding nursing curricula, educationists should consider

*Correspondence: Leighsa Sharoff; Email: lsharoff@hunter.cuny.edu; Address: School of Nursing, Hunter College, United States.

novel approaches to augment students' genomic foundational knowledge. Reiterating required core competencies while threading them throughout a students' educational preparation requires educators to be creative and innovative utilizing dynamic pedagogical strategies. Integrating an evolving simulation scenario of a Cystic Fibrosis (CF) patient can facilitate concepts of genomics, nursing care, and patient advocacy while enhancing students' confidence and comfort level.

This research paper describes a study that used simulation-supported scenarios infused with genomic principles to increase undergraduate nursing students' knowledge of the disease of Cystic Fibrosis and its genomic implications. The primary aim of this study explored how a genetic component in a CF simulation scenario could enhance pre-licensure baccalaureate nursing students' self-perceived ability to integrate genomics into their nursing knowledge base. A second aim explored students' confidence in their ability to participate in patient care. This current research was an extension of a pilot study by the researcher that explored a genetic component integration during a simulation of a patient newly diagnosed with CF at 3 weeks old.[2] This same simulation scenario, plus three newly developed simulation scenarios (expounded by the researcher), were utilized for this current study. Hence, the simulation scenarios were an evolving case study of a patient newly diagnosed at 3 weeks old and three subsequent scenarios at 6 years old, 26 years old and 47 years old. An identical nine-item pre/post simulation learner survey of Cystic Fibrosis knowledge was utilized.

2. Background

2.1 Simulation

Evidence on simulations' effectiveness as a teaching-learning modality has recognized validity, reliability, and legitimacy in nursing education. Studies on simulation demonstrates how it enhances student's knowledge, skills and independent learning;[2,3] promotes professional attitudes and elevates confidence while decreasing anxiety;[4] integrates theory to practice; promotes decision-making abilities, critical thinking and reasoning;[2,4–6] and fosters patient outcomes and safety.[7,8] Scenarios in emergency preparedness;[9] Cystic Fibrosis integration;[2] interprofessional teamwork and communication skills[10,11] are just a few examples of simulation in nursing education.

A quasi-experimental study explored simulation's effectiveness in developing pediatric nursing students skills and clinical reasoning competency.[5] Forty-five participants were evaluated with a pre/post and follow up assessment with results demonstrating their theoretical knowledge improved after simulation.[5] One study explored nursing care skills of a five-month-old infant with bronchopneumonia, nasal obstruction, coughing and wheezing.[12] Participants were randomly assigned to an experimental simulation experience (n = 23) and control (n = 34) groups. Significant statistical differences between the experimental and control groups were evident as well as the knowledge scores.[12] Simulation training is beneficial to student's overall knowledge, skills and confidence levels while enhancing their clinical application of nursing interventions. Twenty-four pre-licensure baccalaureate nursing students participated in a novel pilot study of a Cystic Fibrosis simulation scenario.[2] Results revealed participants' genetic comprehension of Cystic Fibrosis improved after simulation, enhancing learning outcomes, critical thinking and reasoning.[2] Findings from an early post-test descriptive study of a simulation scenario incorporating Sickle Cell Disease showed that the 31 participants' self-perceived genomic knowledge after simulation improved.[13]

2.2 Cystic fibrosis

Cystic Fibrosis, a progressive autosomal recessive disease, affects the pulmonary system, pancreas, and other organs of every racial and ethnic group.[14] According to the Cystic Fibrosis Foundation (CFF) Patient Registry, there are close to 40,000 children and adults living with CF in the United States. An estimated 105,000 people have been diagnosed with CF across 94 countries, with Ireland, United Kingdom and Belgium being the countries with the highest prevalence.[15] There are approximately 1,000 newly diagnosed cases each year; more that 75 percent are diagnosed by age 2 and more than half of the CF population is 18 years old or older.[14,16]

Cystic fibrosis is caused by mutation in the gene that produces the cystic fibrosis transmembrane conductance regulator (CFTR) protein. Every individual inherits two CFTR genes, one from each parent. Individuals who inherit one variant CFTR gene and one unaffected CFTR copy are considered CF carriers. CF carriers do not have the disease but can pass their CFTR variant copy to their offspring. There is a 25 percent chance of transmitting CF to an offspring if the parents are both CFTR mutation carriers; a 50 percent chance the offspring will be a carrier of a mutated CFTR gene; and a 25 percent chance that the child will be a non-carrier.[14] These statistics are for every pregnancy. Individuals who have CF can also transmit copies of their CFTR gene mutations to their children. Thus, if a parent with CF reproduces with an individual who is a CF gene carrier, there is a 50 percent their child will have CF and 50 percent chance the child will be a carrier.[14]

A mutation in the CFTR gene leads to a dysfunctional CFTR protein. There are more than 1,700 known mutations of CF,

the most common being F508del. Approximately 70 percent of CF patients are diagnosed with the F508del variant, a deletion of phenylalanine at residue 508 (delta F508) of the CFTR gene.[14,17] Symptomology includes salty-tasting skin; persistent unproductive cough; recurring pulmonary infections; wheezing and/or shortness of breath; poor growth/weight gain; steatorrhea; and constipation.[18,19] Males with CF (approximately 97%-98%) are infertile due to an absence of the sperm canal, known as congenital bilateral absence of the vas deferens (CBAVD).[14,17,20] These men produce sperm, but the sperm does not make it into the semen, making it impossible to reach and fertilize an egg through coitus.[17,20]

2.3 Genomics and nursing education

Genomics is the study of the complete set of genes (the genome), how genes work, and epigenic interactions.[21] It is a multifaceted interdisciplinary investigational science incorporating genetics, which is the study of how genes and traits are passed down from one generation to the next.[21] The genomic-era has transformed the understanding of complex diseases, of genotype-phenotype relationships and how health information is constructed and translated into novel medicine and patient care practices.[21] The genomic transformation of healthcare is underway and integration across nursing is required.[22,23] Recent studies have shown that genomic content in the core curriculum of undergraduate and graduate programs is insufficient[11,22,24] and the global need to integrate genomics is warranted.[25]

3. METHODOLOGY

Three surveys were utilized to garner data for the evolving CF simulation intervention groups: (1) a nine-item pre-simulation /post-simulation learner survey of Cystic Fibrosis knowledge, as shown in Table 1. Descriptive comparison of the averages for the groups of students consisted of correct response percentages and standard deviation frequencies; (2) a five-item, post-simulation, self-perception survey of learner Cystic Fibrosis knowledge utilized a Likert scale, as shown in Table 2; and (3) one open-ended qualitative question provided supplementary qualitative information. As shown in Table 3, a control group did not receive the CF scenario for their assigned simulation but completed the nine-item learner survey of Cystic Fibrosis knowledge. Data collection, with Institutional Review Board (IRB) approval, occurred during Spring 2019. Completion of anonymous surveys signified consent.

All potential participants were assigned to one of the four CF intervention scenarios and were informed about the research component at the beginning of their pre-conference simulation experience. The simulation technologist read the IRB approved recruitment script. If a participant were interested in volunteering, they could take a Survey Packet. The first page of the Survey Packet was an Information Sheet, which explained why they were being asked to participate in this research study as well as informed the student that there is no 'formal consent procedure.' Key information stated that participation was voluntary and nonparticipation would have no impact on academic standing or grade. Instructions for participation were: 1) prior to the pre-conference discussion beginning, complete the attached nine-item pre-simulation learner survey of Cystic Fibrosis knowledge.; 2) after assigned simulation experience and prior to the post-conference debriefing, complete the attached nine-item post-simulation learner survey of Cystic Fibrosis knowledge and a five-item, post-simulation, self-perception of learner knowledge surveys and 3) when completed, slip the sealed Survey Packet envelop in the secure locked bin.

One randomly chosen clinical group in each educational level, six control groups in total, were asked to complete only the nine-item learner survey of Cystic Fibrosis knowledge. The simulation technologist read the IRB approved recruitment script for the control group. If a participant were interested in volunteering, they could take the Control Group Knowledge Survey, which consisted of an information sheet and the same nine-item learner survey of CF knowledge. They were instructed to complete the knowledge survey prior to their pre-conference and slip their sealed envelope in the secure locked bin. Only the researcher had the key to the secure locked bins. Under no circumstances did non-research personnel have access, nor store, participant surveys. There was no penalization or coercion as the researcher was not present during any of the assigned simulations which were conducted at the SON Simulation Center.

3.1 Study design

All pre-licensure nursing students were assigned to a simulation experience as part of their clinical rotation with their clinical educator as the simulation facilitator. Each educational clinical group had approximately 8-10 students. The researcher did not enroll students into their clinical placement. The researcher, who was the Simulation Coordinator for the School of Nursing (SON) and was responsible for the simulation schedule at the time of this study, assigned all students to a simulation experience based on their clinical day. The researcher created the four CF simulation scenarios that were assigned to three different educational levels: (a) sophomore (2nd yr); (b) junior (3rd yr) and (c) senior (4th yr). The four evolving CF simulation scenarios were developed to complement the core educational didactic course which had a corresponding required clinical.

All students and experienced clinical nurse educators received the simulation schedule and prebriefing preparatory material in advance, which was developed by the researcher. All students prebriefing preparatory material consisted of explanations of the various roles during the simulation, YouTube videos; social/medical history; scenario information; laboratory results; medication orders and simulation learning objectives. All clinical educators separately received their prebriefing preparatory material as it was extremely detailed with information intended only for the educator. In addition to the students prebriefing preparatory information being embedded, instructors received a detailed overview of the simulation scenario; expected student assessments and patient/family education; proposed correct treatment plan with time-frames; comprehensive debriefing/guided reflection content; pathophysiology; genetic content and genomic inheritance patterns; symptomology; treatment modalities and numerous potential nursing diagnoses.

The researcher assigned the CF simulation scenarios to experienced nurse educators, given their familiarity with the simulation process and having conducted simulations in prior semesters. As such, the scenarios were assigned based on the educators' simulation expertise and students' educational clinical level. Given that students were randomly assigned to a clinical rotation, random participant allocation method was the approach. All but the junior level were traditional four-year track students. The junior level (3rd yr) had both traditional and accelerated educational track students. Accelerated students already have a Bachelors' degree and were enrolled in the nursing program to obtain their RN license at a quicker educational pace. Both the junior level accelerated and the traditional students' simulation scenario were assigned either the 3 week old or 6 year old simulated scenario. Traditional and accelerated students had their own assigned clinical experiences and students were not combined.

3.1.1 *Evolving cystic fibrosis simulation scenarios*

As shown in Table 4, the evolving Cystic Fibrosis scenarios provided nursing students with a patient at various stages of their lifespan. The fictitious simulated patient was named Michael Porway. The CF simulation scenario for each educational level were: (a) sophomore level (2nd yr/Adult Health and Illness course) with the Mr. Porway being 26 years old admitted for a severe respiratory infection; (b) junior level (Nursing Care of Infants, Children & Adolescents course), comprised of both traditional students and accelerated students. The 3 week old scenario presented a newly diagnosed patient admitted for a CF assessment while the 6 year old case presented a pediatric patient admitted with a respiratory infection related to CF; and (c) graduating senior students (4th yr/Gerontological Nursing course). This scenario was purposefully developed to be the most difficult with Mr. Porway being 47 years old and experiencing Cystic Fibrosis-Associated Liver Disease (CFLD) and Cystic Fibrosis Related Diabetes (CFRD).

3.1.2 *Participants*

Of the 103 participants who completed the nine-item pre/post simulation learner survey of Cystic Fibrosis knowledge, 82 female and 21 males with an average age of 23 years. The control group had forty females and six males, 23 years average age. All participants were pre-licensure baccalaureate nursing students.

3.2 Instruments

3.2.1 *Pre/post simulation learner survey of cystic fibrosis knowledge*

An identical nine-item pre/post simulation learner survey of Cystic Fibrosis knowledge was utilized to glean students' basic genomic knowledge on CF. This open-domain multiple choice survey, 'What Do You Know About Cystic Fibrosis?'[26] was utilized for the initial pilot study.[2] Initially, this survey had ten questions. Agreement to remove one question for the pilot study was based on the review of an expert clinician and researchers' opinion that students would consider that one specific question confusing.[2] The nine questions investigated relevant CF genetic knowledge such as: CF manifestations; pathophysiological alterations pertaining to the digestive system and mucus glands; CF diagnosis, medical management/treatment care options and risk factors. As of 2024, the updated survey had eight questions.[26]

3.2.2 *Learner survey of cystic fibrosis knowledge survey*

A five-item post-simulation, self-perception of learner knowledge survey gathered students' self-perception of their CF genomic. This five-question survey used a Likert scale ranging from strongly agree/1 to strongly disagree/4. It was previously utilized by the investigator in the initial pilot study[2] and explored students' genetic knowledge; competence to educate patient/family about CF; comprehension to deliver effective and applicable nursing care and interventions; critical thinking and judgment skills in delivering CF genetic information.

3.2.3 *One open-ended qualitative question*

The open-ended qualitative question asked participants to share if they "felt that this scenario enhanced their overall ability to integrate genomics into their knowledge base of nursing and nursing care." The additional data, from a qualitative attribute, enriched the quantitative data. There was no identifiable information requested except for gender, age, and educational clinical level.

3.3 Statistical analysis

Quantitative data were coded and entered into an SPSS database for analysis. A priori power analysis was conducted using G*Power (version 3.1.9.7) to estimate the minimum sample size required to detect a medium effect size (Cohen's d = 0.50) with a statistical power of 0.80 and an alpha level of 0.05. Results indicated that a total sample size of 50 participants was sufficient to detect statistically significant differences between two independent groups using a two-tailed independent samples *t*-test. The final sample consisted of 103 participants in the intervention group and 46 participants in the control group.

An analysis of variance (ANOVA) revealed a statistically significant group difference ($p = .04$), with a corresponding 95% confidence interval and an effect size of Cohen's d = 0.50, thereby strengthening the internal validity and interpretability of the findings. Descriptive statistics, including mean percentage of correct responses and associated standard deviations, were tabulated to compare performance across student groups. Post-simulation knowledge gains in genomic literacy were evaluated using item-level analysis of survey responses.

Qualitative data from open-ended survey items were analyzed using thematic analysis, incorporating inductive coding and cluster-based pattern recognition to identify emergent themes. From this analysis, data-driven suppositions were generated through a systematic and objective interpretative process.

The instruments employed in this study had been previously validated in similar educational and clinical contexts. Their psychometric properties, established through prior testing, support both construct validity and internal consistency reliability. Instrument selection was closely aligned with the research objectives, target population, and measured constructs, thereby ensuring methodological rigor and facilitating comparability between pilot data and the current study. Potential biases in data collection were mitigated through the use of pre-validated instruments that had undergone prior evaluation for content validity and error susceptibility.[2]

3.4 Limitations

A significant limitation was that data collection from the respondents on the pre/post simulation learner survey of Cystic Fibrosis knowledge and the learner survey of Cystic Fibrosis knowledge did not allow for pairing to a particular individual, thus only the averages of the group data was obtained and not paired analyses. An additional limitation may be the size of the control group (n = 46) being less than half the size of the intervention group (n = 103). As this study occurred at one campus location of a university, only those students assigned to the CF simulation scenarios were eligible, minimizing generalization. Students' self-perceived knowledge can be viewed as a constraint as it was not actual knowledge. Possible confidentiality violation could be perceived as surveys were completed prior to post-conference. There was no privacy expectancy as the clinical group may have been aware of any individual who chose not to partake. However, this limitation was discussed in the information sheet and no identifiable data was collected. The quasi-experimental design, with a comparison group and both quantitative and qualitative data collection, promotes evidence triangulation, thereby enhancing the reliability of the findings and the depth of the analysis.

4. Results

4.1 Compared averages of participants

This study descriptively compared averages of the groups of students who were assigned the CF intervention simulation scenario. A total of 103 pre-licensure students completed the anonymous voluntary nine-item pre/post simulation learner survey of CF knowledge. Twenty-eight traditional sophomore level students (2nd yr) completed the young adult CF scenario. Nine accelerated and 15 junior (3rd yr) students completed the 3 week old CF scenario. Ten accelerated and 23 junior students completed the pediatric 6 year old CF scenario while 18 senior students (4th yr) completed the older adult CF scenario. Forty-six students comprised the control group and completed only the nine-item learner survey of CF knowledge. Of those, eight sophomore (2nd yr) completed the young adult CF survey. Six accelerated and eight traditional (3rd yr) students completed the 3 week old while nine accelerated and seven traditional students (3rd yr) completed the pediatric 6 year old survey. Finally, eight senior (4th yr) students completed older adult CF survey.

4.2 Pre/post simulation learner survey of cystic fibrosis knowledge

As shown in Table 1, all of the six collective intervention groups total post-simulation knowledge averages improved or remained the same as pre-simulation CF knowledge. Comparatively, all total post-simulation CF knowledge averages were considerably higher than the control group CF knowledge averages, which is shown in Table 3.

Table 1. Pre/post simulation learner survey of cystic fibrosis knowledge [Percentage of Correct Responses]

Survey Question	Pre Simulation Knowledge (Student Groups)								Post Simulation Knowledge (Student Groups)							
	S=28	T=15 3 wks	A=9 3 wks	T=23 6 y/o	A=10 6 y/o	Sn=18	AVG	SD	S=28	T=15 3 wks	A=9 3 wks	T=23 6 y/o	A=10 6 y/o	Sn=18	AVG	SD
Cystic Fibrosis [CF] affects which body system? A: Respiratory and Digestive	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	94.4 (n=17)	85.4 (n=88)	5.4	100 (n=28)	100 (n=15)	100 (n=9)	100 (n=23)	100 (n=10)	94.4 (n=17)	99.0 (n=92)	3.5
Which symptom in an infant or young child might indicate CF? A: All of the Above	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	83.3 (n=15)	83.4 (n=86)	6.1	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	83.3 (n=15)	96.5 (n=99)	6.3
What happens to the mucus glands in a child with CF? A: The mucus is thick and over produced.	100 n=28	100 (n=15)	88.9 (n=8)	95.7 (n=22)	100 (n=10)	88.9 (n=16)	83.4 (n=86)	5	100 (n=28)	100 (n=15)	100 (n=9)	100 (n=23)	100 (n=10)	100 (n=18)	100 (n=103)	6.2
How is the digestive system affected by excess mucus in CF? A: Mucus clogs the ducts of pancreas and damages bile ducts in the liver.	73.3 (n=20)	73.3 (n=11)	66.7 (n=6)	95.7 (n=22)	90 (n=9)	94.4 (n=17)	73.8 (n=76)	11.5	73.3 (n=20)	73.3 (n=11)	88.9 (n=9)	95.7 (n=22)	100 (n=10)	94.4 (n=17)	87.6 (n=89)	13.6
How is CF diagnosed? A: Sweat & Blood Test	93.33 (n=26)	93.3 (n=14)	77.8 (n=7)	70.8 (n=17)	90 (n=9)	55.6 (n=10)	68.9 (n=71)	13.8	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	61.1 (n=11)	92.8 (n=95)	19.3
Currently no effective treatment is available to correct the cause of CF. Doctors can, however, slow the progression of the disease. Which of these medications can do this? A: Bronchodilators, Antibiotics, Decongestants, Mucolytics.	100 (n=28)	100 (n=15)	88.9 (n=8)	95.7 (n=22)	100 (n=10)	100 (n=18)	85.4 (n=88)	4.1	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	100 (n=18)	86.4 (n=89)	1.6
A defect in a gene that produces the protein cystic fibrosis transmembrane regulator is the cause of CF. According to recent research, this abnormality results in an imbalance of which key substance in the body? A: Fatty Acids	66.67 (n=19)	66.7 (n=10)	22.2 (n=2)	52.2 (n=12)	20 (n=2)	44.4 (n=8)	42.7 (n=44)	18.9	66.67 (n=19)	66.7 (n=10)	44.4 (n=4)	69.7 (n=16)	30 (n=10)	50 (n=9)	57.3 (n=59)	14.4
CF is a genetic, or inherited disease. How is CF passed down through families? A: Both families are carriers of the CF gene.	80 (n=22)	80 (n=12)	77.8 (n=7)	60.7 (n=14)	90 (n=10)	66.7 (n=12)	53.1 (n=67)	9.6	93.33 (n=26)	93.3 (n=14)	100 (n=9)	69.7 (n=16)	90 (n=9)	66.7 (n=12)	85.5 (n=86)	18.5
Who is most at risk for Cystic Fibrosis? A: Caucasians of Northern European descent.	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	100 (n=18)	86.4 (n=89)	1.6	100 (n=28)	100 (n=15)	100 (n=9)	95.7 (n=22)	100 (n=10)	100 (n=18)	99.2 (n=102)	3.1

Notes. S = Sophomores (2nd year); T = Traditional 4 year undergraduate students (3rd year/Juniors); A = Accelerated students (3rd year/Juniors); Sn = Seniors (4th year); Pre/Post Simulation Student Total Groups n=103
n = number of participants who answered correctly

Table 2. Learner survey of cystic fibrosis knowledge survey

Survey Question (n=103)	Strongly Agree	Agree	Disagree	Strongly Disagree
Your understanding of the genetic/genomic component of CF improved after this simulation experience.	23.3 (n=24)	64.1 (n=66)	6.8 (n=7)	5.8 (n=6)
Your ability to provide the patient and family with information pertaining to CF was satisfactory.	24.3 (n=25)	68 (n=70)	3.9 (n=4)	3.9 (n=4)
Your level of understanding of CF was appropriate to provide effective and efficient nursing care with appropriate nursing interventions.	27.2 (n=28)	66 (n=68)	5.8 (n=6)	.97 (n=1)
Your critical thinking skills about providing genetic information to a patient in this situation have improved.	23.3 (n=24)	64.1 (n=66)	8.7 (n=9)	3.9 (n=4)
Your clinical judgment about providing genetic information to a patient in this situation has been improved.	20.9 (n=21)	68.9 (n=71)	7.8 (n=8)	2.9 (n=3)

Table 3. Control group of learner survey of cystic fibrosis knowledge [Percentage of Correct Responses]

	S=8	T=8 3 wks	A=6 3 wks	T=7 6 y/o	A=9 6 y/o	Sn=8	AVG	SD
Cystic Fibrosis [CF] affects which body system? A: Respiratory and Digestive	100 (n=8)	100 (n=8)	100 (n=6)	100 (n=7)	88.9 (n=8)	100 (n=8)	97.8 (n=45)	4.1
Which symptom in an infant or young child might indicate CF? A: All of the Above	75 (n=6)	75 (n=6)	100 (n=6)	85.7 (n=6)	77.8 (n=7)	75 (n=6)	80.4 (n=37)	9.3
What happens to the mucus glands in a child with CF? A: The mucus is thick and over produced.	100 (n=8)	100 (n=8)	100 (n=6)	100 (n=7)	88.9 (n=8)	100 (n=8)	97.8 (n=45	4.1
How is the digestive system affected by excess mucus in CF? A: Mucus clogs the ducts of pancreas and damages bile ducts in the liver.	100 (n=8)	100 (n=8)	83.3 (n=5)	100 (n=7)	100 (n=9)	75 (n=6)	93.5 (n=43)	10.1
How is CF diagnosed? A: Sweat & Blood Test	100 (n=8)	100 (n=8)	100 (n=6)	100 (n=7)	89.9 (n=8)	37.5 (n=3)	87 (n=40)	22.8
Currently no effective treatment is available to correct the cause of CF. Doctors can, however, slow the progression of the disease. Which of these medications can do this? A: Bronchodilators, Antibiotics, Decongestants, Mucolytics.	87.5 (n=7)	87.5 (n=7)	100 (n=6)	100 (n=7)	100 (n=9)	75 (n=6)	91.3 (n=42)	9.3
A defect in a gene that produces the protein cystic fibrosis transmembrane regulator is the cause of CF. According to recent research, this abnormality results in an imbalance of which key substance in the body? A: Fatty Acids	25 (n=2)	25 (n=2)	25 (n=2)	42.9 (n=3)	11.1 (n=1)	37.5 (n=3)	28.3 (n=13)	9.5
CF is a genetic, or inherited disease. How is CF passed down through families? A: Both families are carriers of the CF gene.	75 (n=6)	75 (n=6)	50 (n=3)	57.1 (n=4)	77.8 (n=7)	62.5 (n=5)	67.4 (n=13)	10.4
Who is most at risk for Cystic Fibrosis? A: Caucasians of Northern European descent.	87.5 (n=7)	87.5 (n=7)	100 (n=6)	100 (n=7)	100 (n=9)	100 (n=8)	95.7 (n=44)	5.9

Notes. S = Sophomores (2nd year); T = Traditional 4 year undergraduate students (3rd year/Juniors); A = Accelerated students (3rd year/Juniors); Sn = Seniors (4th year); Control Group total n=46; n = number of participants who answered correctly.

Twenty-eight sophomore students' pre-simulation average was 74.6 with a post-simulation average of 78.9. The corresponding control group (n = 8) average was 60. Fifteen traditional juniors who had the 3 week old simulation pre/post average remained the same at 83.3 while the control group of eight student was 77.5. The 23 traditional students who had the pediatric 6 year old scenario averaged 77.4 for pre-simulation and had an increase to 81.3 post-simulation. The corresponding seven control group students had an average of 78.57. The nine accelerated students assigned to the 3 week old simulation had a pre-simulation average of 73.3 which increased to 81.1 post-simulation while the six control group averaged 80. The 10 accelerated students assigned to the pediatric 6 year old case had a pre-simulation average of 82 with a post-simulation average of 86. The corresponding nine students in the control group averaged 75.6. Finally, the

18 seniors pre/post simulation CF knowledge remained the same at 78.9 while the eight control group students' averaged 68.75.

4.3 Learner survey of cystic fibrosis knowledge survey

As shown in Table 2, only the groups receiving the simulation intervention completed this tool and the data was derived from their perceptions. All five survey items had the majority of participants strongly agreeing/agreeing improvement in their genomic knowledge post simulation. Self-perceived genetic knowledge was 87.4 (n = 90); ability to provide pertinent CF information to patient/family had 92.3 (n = 95); CF comprehension to provide appropriate nursing care and interventions effectively and efficiently was 93.2 (n = 96); critical thinking skills improved 87.4 (n = 90) while clinical judgment improved 89.8 (n = 92).

Table 4. Overview of Simulated Case Scenarios of Michael Porway

Student Educational Level	Age of Simulated Patient	Michal Porway – Simulated Case Scenario Overview
Sophomore (2nd yr) Adult Health and Illness	26 years old	This case presented a patient admitted with for Cystic Fibrosis with a severe respiratory infection. The patient had scarring on his lungs which led to significant malfunctioning in his pulmonary functioning and was currently on the verge of respiratory failure. The scarred tissue made his lungs incompetent. He was underweight and malnutrition. Consideration on putting Mr. Porway on a list for a lung transplant was addressed.
Junior (3rd yr) Nursing Care of Infants, Children & Adolescents	3 weeks old	This case presented a newly diagnosed patient admitted for Cystic Fibrosis assessment. Patients' parents did not understand the genetic relationship and were asking the nurse to explain what was happening. The students were expected to perform a general assessment, pain assessment and patient care. The students were expected to provide genetic education for the patient and family on CF. As genomics is a required competency, knowing how to explain this condition would help the students gain a deeper understanding of this requirement.
Junior (3rd yr) Nursing care of Infants, Children & Adolescents	6 years old	This case presented a pediatric patient admitted with a respiratory infection related to Cystic Fibrosis. The students were expected to perform a general assessment, respiratory assessment and all nursing care. The students were expected to provide genetic education for the patient and his family on severe respiratory infection related to CF. As genomics is a required competency, knowing how to explain this condition would help the students gain a deeper understanding of this requirement.
Senior (4th yr) Gerontological Nursing	47 years old	This case presented a patient with Cystic Fibrosis-Associated Liver Disease [CFLD] and Cystic Fibrosis Related Diabetes [CFRD]. He was underweight and had malnutrition syndrome. Discussion regarding hospice care was addressed.

4.4 Open-ended qualitative question

Participants were asked to share if they felt that their assigned scenario enhanced their overall ability to integrate genomics into their knowledge base of nursing and nursing care. Three major themes emerged from the rich qualitative data with seven sub-themes. Improved knowledge and comprehension of genomics in nursing had 42.8% which described the value in applying knowledge from didactic education in a simulation experience. Simulation was able to solidify comprehension of genomics in a clinical learning environment. Two sub-themes were identified: understanding CF and applying nursing interventions and critical thinking skills. The second theme, family and patient education skills in nursing demonstrated how students embraced the importance of understanding the genomics and disease process of CF. They learnt to effectively explain the process of CF with confidence while providing thorough patient and family care. Three sub-themes were revealed: patient-centered care; confidence and teaching and explaining. Lastly, students expressed their appreciation for an opportunity to apply hands-on skills in a controlled clinical learning setting in the theme of valuing the clinical experience in nursing with subthemes of experience and communication.

5. Discussion

These outcomes align with the findings of Huang;[5] Sari et al.,[12] and Author.[2] In this study, participants knowledge of Cystic Fibrosis increased after simulation. Participants' overall theoretical knowledge of CF post simulation was significantly higher than the control group. Simulation provides

a reliable and valid pedagogical educational strategy, not only for cognitive, psychomotor and affective learning, but also for genomic proficiency. Acquiring theoretical knowledge and clinical nursing skills through simulation is an effective pedagogical strategy.[2,5,12]

Attaining theoretical knowledge and nursing skills through simulation integration can bridge the gap between didactic knowledge and skills application.[5] Student's theoretic comprehension of CF predisposition, patterns of inheritance and diagnosis improved post-simulation, with 87.4% agreeing that their understanding of the genomic component of CF improved. Clinical reasoning, decision-making and critical thinking skills are developed through simulation promoting students' confidence and self-efficacy.[2,4,6] This was expressed by participants stating, "The scenario enhanced... overall ability to understand CF... what nursing interventions... needed to help... patient;" "It helped... develop... critical thinking skills;" "... it improved... level of patient-centered care."

Critical thinking skills and clinical judgement improved post simulation, with 87.4% and 89.8% respectively, agreeing. The knowledge survey question 'What happens to the mucus glands in a child with CF?' had post-simulation correct responses of 100% by all participants. The knowledge survey question 'CF is a genetic, or inherited disease. How is CF passed down through families?' had an increase in correct responses by all participants post-simulation. All of the control groups had lower correct responses to this survey item. Statements by participants on the importance of genomic knowledge further exemplifies the importance of continuing this core competency through-out students' education process: "... genomics... important... able to answer... questions using... knowledge learnt;" "can now understand... foundation of this disease" and "understood how genetics... responsible for the development of CF."

Providing students with opportunities to apply hands-on application of skills in a controlled setting promotes confidence. Comprehending appropriate nursing interventions and patient treatment modalities can be enhanced during a simulation experience.[12,13,27] This was corroborated with 93.2% agreeing that their level of understanding of CF was appropriate to provide effective and efficient nursing care with appropriate nursing interventions post-simulation. Participants' ability to provide the patient and family with pertinent CF information after simulation also improved post simulation with 92.3% agreeing. This was further confirmed with participants' statements of enhanced understanding of effective treatment modalities, expressed as "more aware of nursing care actions... pathophysiology, etiology... treatment options." Students learn from doing while gaining independent knowledge and understanding,[3] as participants stated having "more confidence... communicating nursing care... provided hands-on experience... what will see in real life". Findings from this study support the perspective that simulation could assist students to achieve the learning objectives and outcomes. Enhancing knowledge through simulation is an effective supplemental educational strategy, as it is a learner-centered pedagogical approach ensuring students learning outcomes are achievable. The value in applying knowledge from didactic education through simulation was demonstrated by participants sharing how they "feel better prepared for... clinical setting" and "this scenario helped me understand and critically analyze the depth of symptoms of CF and CF patient experiences."

Simulation provides opportunities to integrate theory to practice while ensuring patient outcomes and safety.[4,7,8] The vast amount of knowledge nursing students must acquire and utilize is inestimable. They need to collect, assess and analyze patients' subjective and objective data to ascertain the best course of evidence-based practice. Students' knowledge retention can be enriched through simulation experiences.[4] Confidence in one's abilities to perform nursing care corresponding to clinical competence and improved communication aptitudes can also be enriched with simulation.[11,12] Ensuring that genomics is threaded through curricula, through innovative simulation scenarios, provides additional opportunities for students to become adept with this competency. Simulation is able to enhance comprehension of genomics in a clinically-based setting. This study purports the inclusion of genetically-based conditions that can achieve multiple competencies through simulation.

Implications for professional nursing development

It is essential that educators continue to expound on creative and innovative educational strategies to proactively engage students to achieve their highest learning potential. Engaging students with an interesting and novel approach to learning genomic content is an important aspect for educators. Combining pedagogical methodologies and core competencies is a beneficial teaching strategy to meet learning outcomes. The use of evolving clinical cases throughout the semester stimulates clinical reasoning, contextual learning, and knowledge transfer to practice, which are key features of competency-based education.

6. Conclusion

Simulation solidifies comprehension of genomics application of knowledge from didactic theory to practice experiences. Opportunities to enhance students' abilities to research a

condition, practice patient teaching, improve their critical thinking and judgment skills through nursing care augments their foundational communication, competence, and knowledge proficiency. Reiterating core competencies by threading throughout curriculum, requires educators to be creative and innovative utilizing dynamic pedagogical strategies. Simulation is a valid and effective teaching-learning format yet a notable gap in research exists in genetically-based case-scenario integration.

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Dr. Leighsa Sharoff was responsible for study design, revising, reading and approving the final manuscript.

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The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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