Strategic Modeling of the Pediatric Nurse Practitioner Workforce

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Abbreviations: NP—nurse practitioner; PNP—pediatric nurse practitioner; RN—registered nurse

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What's Known on This Subject
The number of nurse practitioner graduates in the United States has nearly doubled over the past two decades. However, the number of pediatric nurse practitioner (PNP) graduates has remained relatively flat while the demand for PNPs is expected to increase.

What This Study Adds
This study estimates the best-case shortage of PNPs over the next 25 years. We propose possible policy interventions to address key areas of the PNP workforce system and we compute their impact on the forecasted PNP shortage.

Contributor's Statements:

Greggory J. Schell: Mr. Schell drafted the initial manuscript, assisted in the collection of data, analyzed and interpreted the results, and approved the final manuscript as submitted.

Mariel S. Lavieri, Alejandro Toriello: Drs. Lavieri and Toriello conceptualized and designed the study, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Xiang Li: Mr. Li assisted in the collection of data, analyzed and interpreted the results, and approved the final manuscript as submitted.

Kristy K. Martyn, Gary L. Freed: Drs. Martyn and Freed conceptualized and designed the study, assisted in the collection of data, reviewed and revised the manuscript, and approved the final manuscript as submitted.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Abstract

Objective
To assess the current pediatric nurse practitioner (PNP) workforce and investigate the impact of potential policy changes to address forecasted shortages.

Methods
We modeled the admission of students into nursing bachelor's programs and followed them through advanced clinical programs. Prediction models were combined with optimal decision making to determine best-case scenario admission levels. We computed two measures: (1) the absolute shortage and (2) the expected number of years until the PNP workforce will be able to fully satisfy PNP demand (i.e. self-sufficiency).

Results
There is a forecasted shortage of PNPs in the workforce over the next 13 years. Under the best-case scenario, it would take at least 13 years for the workforce to fully satisfy demand. Our analysis of potential policy changes demonstrated that increasing the specialization rate for PNPs by 4 % would decrease the number of years required until there are enough PNPs from 13 years to 5 years. Increasing the certification exam passing rate to 96% from the current average of 86.9% would lead to self-sufficiency in 11 years. And increasing the annual growth rate of master's programs to 36% from the current maximum of 10.7% would result in self-sufficiency in 5 years.

Conclusion
Current forecasts of demand for PNPs indicate that the current workforce will be incapable of satisfying the growing demand. Policy changes can result in a reduction in the expected shortage and potentially improve access to care for pediatric patients.

Introduction

Analysis of the aggregate nurse practitioner (NP) workforce reveals a near doubling in the number of nurse practitioner (NP) graduates in the United States since 1996. However, this supply increase has not been equitable across the NP specialties. Family nurse practitioners (FNP) have experienced the largest growth of graduates while the number of new pediatric nurse practitioner (PNP) graduates has remained relatively flat.[1] Furthermore, the majority of states currently have fewer than 25 PNPs per 100,000 children.[2] This supply of PNPs will be unable to meet the demonstrated increasing demand in both pediatric primary care practices and subspecialty clinics.[3] In particular, the competition between primary and subspecialty pediatric practices for the limited supply of PNPs will likely lead to difficulties in accessing pediatric subspecialty services.[4] A failure to address these pediatric health workforce concerns will affect pediatric care and will have long-term consequences on the health of the entire population.[5,6]

It has been hypothesized that the rising demand for pediatric services is due in part to increased survival rates and disease burden of children with chronic illnesses, including obesity, diabetes and asthma.[7] In addition, the increased prevalence of delayed childbearing is leading to low birth weights and complications necessitating additional pediatric care.[8] There has also been a significant shift in the proportion of child health visits from family physicians to pediatricians.[9] PNPs are increasingly providing independent care to patients with complex diseases and working collaboratively with attending physicians to manage the increased demand for pediatric service.[10,11] Given the rising demand as well as the key role of PNPs in providing pediatric care, we focus on modeling the workforce system of PNPs.

Modeling the aggregate nursing workforce or even the aggregate NP workforce is insufficient for detecting and addressing the challenges faced specifically in the PNP supply. Rather, a systematic framework is needed for modeling the workforce challenges of PNPs in order to identify beneficial interventions for improving access to care. This need for modeling workforce challenges is mirrored in the Affordable Care Act's authorization of a National Health Care Workforce commission and a National Center for Workforce Analysis, whose priorities include identifying methods needed to develop accurate predictions of future workforce needs.[12] The necessity for improved workforce planning models and educational changes has also been echoed by George Thibault, president of the Josiah Macy Foundation[13] and recent studies, including those by Iglehart[14] and Dall.[15] Our work aims to complement the existing literature on the nursing workforce (such as Auerbach[16] and Buerhaus[17]) by including optimal decision making with forecasting models of PNP supply and demand.

To address the worsening scarcity of PNPs and the expanding demand for their professional services, we developed a novel framework for analyzing the PNP workforce in the United States, and present the impact of a variety of policy options that will impact the pipeline of registered nurses (RN) and nursing school students who enter PNP training programs. Using the proposed framework, we provide policy suggestions for addressing the disparity between supply and demand of PNPs. Our work offers insight into the benefit of policy interventions and contributes toward improved workforce planning models.

Methods

We modeled the admission of students into nursing bachelor's programs and followed them

through advanced clinical programs in PNP education (master's programs) or entrance into the

registered nurse (RN) workforce (see Figure 1). Baccalaureate students were categorized as

traditional part-time students, traditional full-time students, part-time RN-to-baccalaureate

students and full-time RN-to-baccalaureate students with 5, 4, 2 or 1 years required to complete

their degree upon admission, respectively. Upon graduation from the nursing baccalaureate

program, the graduated student either entered the RN workforce after passing the RN exam or

enrolled in a NP master's program. Our modeling also allowed employed RNs to exit the

workforce and enroll in a NP master's program, while ensuring a minimum number of RNs to

remain in the workforce. Of those who enrolled in a NP master's program in a given year, the

PNP specialization rate defined the percentage of enrolled NP master's students who selected

PNP as their specialty and hence became PNP master's students. PNP master's students were

categorized as either full-time or part-time students. Full-time master's students completed their

degree in 2 years, while part-time students completed their degree in 3 to 5 years. Upon

graduation from the PNP master's program, the graduated student entered the workforce after

passing the national PNP certification exam. Furthermore, at each education and professional

category (e.g. 3rd year bachelor's student), enrolled students and employed RN and PNPs were

allowed to exit the education or workforce system, i.e. we modeled both education and

workforce attrition. Attrition rates for each category were computed as the percentage of

students/nurses who would leave the education/workforce system each year.

We used data and categories from Enrollment and Graduations in Baccalaureate and Graduate

Programs in Nursing by the American Association of Colleges in Nursing (AACN)[18] to compute

initial population sizes, attrition rates, and graduation rates for baccalaureate and master's nursing students. From the AACN, we also computed the rate of students entering nursing master's programs who specialize in NP and the rate of NP students specializing in PNP. The attrition rate of PNPs from the workforce was computed using recertification rates between 2011 and 2013 from the Pediatric Nursing Certification Board (PNCB).[19] Attrition rate of RNs from the workforce were calculated from the National Sample Survey of Registered Nurses.[20] RN and PNP exam passing rates were calculated from the National Council of State Boards of Nursing,[21] and the PNCB[22] respectively. Data for the initial workforce levels of RNs and PNPs came from the AACN Nursing Shortage Fact Sheet[23] and the National Association of Pediatric Nurse Practitioners 2013 State Map, respectively.[24] Payroll costs for RNs, FNPs, and PNPs came from the U.S. Department of Labor's Bureau of Labor Statistics.[25] Annual demand growth for PNPs in the workforce (5%) was computed as the average annual change in the number of PNPs in the U.S. from 2009 to 2013.[24,26]

We used linear programming to determine optimal admission decisions every year of the planning horizon (25-years) that would lead to satisfying the demand for PNPs.[27] The algebraic formulas used to model the PNP workforce and derive optimal decisions can be found in Lavieri et al.[28] The optimal admission decisions for a particular year are the number of students admitted to nursing baccalaureate programs, the number of bachelor's students admitted to NP master's programs immediately following graduation, and the number of employed RNs admitted to NP master's programs. The linear programming approach combines forecasts of workforce needs with the system's dynamics to determine optimal admission decisions and identify policy interventions which would improve system performance.

We computed two performance measures to assess the quality of the linear programming model's decisions. Our first performance measure was the absolute PNP shortage in the United States over the 25 year horizon. We define shortage as the positive absolute difference between the demand for PNPs (calculated based on an assumed 5% annual demand growth with respect to the current workforce[24]) in a given year and the supply of PNPs in that year; therefore, no shortage occurs whenever the supply of PNPS in a year is equal to or exceeds the demand for PNPS in that year. We assume that demand for PNPs can only be satisfied by PNPs. We also calculated the expected number of years until the PNP workforce system would be able to fully satisfy demand. This performance measure captured how long the system needed to become self-sufficient (i.e. no PNP shortages).

We defined the best-case scenario as the result of following the model's optimal admission decisions under the modeled system's current parameters. We use the best-case scenario as the basis for our analysis, because it highlights the limitations of the current education and workforce system even when viewed conservatively. When not following optimal admission decisions, the forecasted shortages will be magnified.

Furthermore, we performed sensitivity analysis of the system's current parameters to calculate the effect of changing these parameters on the performance measures of the system. This sensitivity analysis provided a robust method for studying the effect of policy changes (e.g. increased funding toward the expansion of PNP master's programs) on the expected number of years until the PNP system is self-sufficient.

Results

Current System

Table 1 presents the base-case values for inputs to the model. The current nursing education and workforce pipeline for PNPs has 299,118 enrolled baccalaureate students, 2,763,000 working registered nurses (RN), 2766 enrolled master's students in PNP programs, and 16584 working PNPs. For the estimated annual PNP demand growth of 5%, even under the best-case scenario for the current PNP system, it would take 13 years to achieve self-sufficiency (i.e. no PNP shortage). The shortage is a result of increased demand for PNPs in the workforce, a constrained education system, and the attrition of currently employed PNPs.

Figure 2 displays the absolute shortage of PNPs in the workforce over the next 25 years for the current system under 4, 5, and 6% annual demand growth. The forecasted shortage depends strongly on the annual demand growth for PNPs. Combining an accurate prediction model with optimal decision making provides estimates of the value of system changes, such as an increased PNP specialization rate.

Next, we present the sensitivity analyses of three potential system changes: increasing the PNP specialization rate, increasing the PNP exam passing rate, and increasing the potential annual enrollment growth rate of PNP master's programs.

PNP Specialization Rate

We started by investigating how making changes to the PNP specialization rate (ranging from 2% to 9%) would affect the number of years required until the system no longer experiences shortages in the best-case scenario. PNP specialization is the percentage of incoming NP master's students who select pediatrics as their nursing specialty. The number of years required to become self-sufficient is highly dependent on the percentage of students obtaining a nurse practitioner master's degree who choose to specialize in pediatrics. As can be seen in Figure 3, increases in PNP specialization would yield a higher supply of NP students pursuing PNP education and a proportionally higher pool of PNPs for satisfying demand. The current PNP specialization rate is 4.9% with a corresponding 13 years until the system is self-sufficient. We found that the ideal PNP specialization rate is 8.9%. This ideal specialization rate achieves the minimum expected number of years until self-sufficiency of 5 years. However, just as improved specialization rates decrease the number of years until self-sufficient, if the specialization rate drops to 3.7%, the PNP shortage is expected to persist for 19 years under the best-case scenario.

PNP Exam Passing Rate

We also studied how PNP national certification exam passing rates influence our performance measure of the expected number of years required until the system is self-sufficient. We computed the current PNP exam passing rate nationwide (86.9%) from the Pediatric Nursing Certification Board 2013. As shown in Figure 4, increases in the PNP exam passing rate would lead to more graduating PNP students certified to perform pediatric care. We found that by increasing the PNP exam passing rate to 96%, the number of years required until self-sufficiency would decrease from 13 to 11. Similarly, if the exam passing rate decreases to 78%, the number of years required until self-sufficiency would increase from 13 to 15.

PNP Master's Program Growth

Under the best-case scenario, the current system will require a near quadrupling in the number of PNP graduates over the next 25 years in order to satisfy the assumed 5% annual demand growth. Over the last five years, we observed a maximum percentage annual increase in the number of master's students of 10.7%. Figure 5 shows the effect of adding flexibility in how much master's programs can grow from year to year. Increasing the potential growth rate of the enrollment size of master's programs leads to larger student populations which enter the workforce following graduation and certification. The expected number of years until self-sufficiency would be reduced to 5 years if the potential annual growth rate increased to 36%. If the potential annual growth rate of enrollment is restricted to 8%, the expected number of years until self-sufficiency would increase to 22 years.

Discussion

Our linear programming model combines optimal decision making with predictions of nationwide PNP demand in order to evaluate the forecasted shortage of PNPs.

Analysis of the current system reveals that even under the best-case scenario, the existing system will not satisfy demand for PNPs in the workforce for at least 13 years. Satisfying this demand requires following the optimal admission decisions determined by our model; the growing PNP demand will not be satisfied by the current system unless changes are made. The insufficient supply of PNPs may constrain access to pediatric care, which can negatively affect children's health. Through sensitivity analysis of our model, we have identified three system changes that would reduce the forecasted PNP shortage and the expected number of years until the system is

self-sufficient: (1) increasing the percentage of NP master's students choosing pediatrics as their specialty, (2) increasing the PNP certification exam passing rate, and (3) increasing the potential annual growth in enrollment of PNP master's programs.

PNP Specialization: Presently, only 4.9% of NP graduate students choose to specialize in pediatric care. The primary reason NP master's students specialize in pediatrics is their desire to work with children.[31] For those who specialized in pediatrics, the primary alternative specialization was FNP.[31] The popularity of FNPs (a doubling in the number of FNP graduates between 1996 to 2008) may be due to their perceived job flexibility in being able to work with patients of any age.[32] In fact, the vast majority of FNPs (93%) treat patients between the ages of 66 and 85 years; and 79% of FNPs treat patients older than 85.[33] Moreover, one-third of FNPs reported they did not provide care to children and for most of those who did report care to children, these children (especially those under eight years old) were a small percentage of their patient populations.[4] Hence, master's students pursuing FNP education with the intention of caring for children during their career may not provide care to children when they are practicing as FNPs. Attention must be paid to these workforce realities during the course of nursing education to ensure students make well-informed career choices. Since many NP students perceive FNP as having higher job availability than PNP, increasing the PNP specialization rate will require improved marketing of PNP as a career at all potential points of nursing career decision-making: before BSN programs, during time as a RN, and upon entrance to advanced education programs. This marketing may take the form of messages from nursing faculty and clinical preceptors to students or through increased media emphasis on the need for PNPs and their unique role in the care of children.

The Robert Wood Johnson Foundation (RWJF) Committee on the Future of Nursing at the Institute of Medicine (IOM) recommends an increase in scholarships, loan forgiveness and institutional capacity awards to increase the number and proportion of newly licensed nurses graduating from higher degree programs.[12] Scholarships and loan forgiveness targeted at PNP graduate students will incentivize specialization in PNP.

While our analysis indicates that an increase in the PNP specialization rate is necessary to meet the demand, more PNPs do not need to come at the expense of other NP specialties. Overall increases in NP enrollment would also satisfy the need for more PNPs without changing the percentage of NPs who choose pediatrics.

PNP Exam Passing Rate: The current national PNP exam passing rate for certification is 86.9%, with variation across the United States. Without certification, in most states a student graduating from a PNP academic program will be unable to practice as a PNP. Thus, while increasing the percentage of NP master's students who choose to specialize in pediatrics will increase enrollment in PNP master's programs, a lower certification exam passing rate will reduce gains in the PNP workforce. There is a need for nursing programs to focus on ways to improve national certification examination pass rates to ensure graduating students are able to join the workforce.

The RWJF/IOM Committee's recommends the promotion of innovation and the evaluation of novel approaches to improving preparation for the practice of nursing through expanded Title

VIII funding.[12] We recommend funding collaborative analysis of educational methods and collaboration of nursing faculty and certification boards to increase the PNP exam passing rate.

Enrollment Size of PNP Master's Programs: There has been an increase in the proportion of NP programs that offer advanced clinical education, but a decrease in the proportion of programs offering PNP education.[1] Furthermore, nursing programs nationwide face a shortage of pediatric faculty members.[32] This reduced exposure to pediatric clinical experience is negatively affecting the nation's ability to satisfy future demand for PNPs. If the interest in PNP specialization increases, the increased demand for PNP education will ideally lead to increases in the number of PNP master's programs and/or the enrollment size of existing PNP programs.

An expansion in the size of PNP graduate education programs will require increased funding for master's programs. The American Nurses Association urges significant increases in federal funding of the Title VIII Nursing Workforce Development programs administered by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services.[34] These programs provide grants to enhance education and practice for master's nursing students. They also include the Nurse Educational Loan Repayment Program which supports students enrolled in nursing with the requirement of at least two years of full-time employment in a facility designated as having a critical nursing shortage. And while comprehensive geriatric education grants assist in the training of nurses to provide for geriatric care, we have identified a need for a similar grant program for pediatric nurse education.

Implementing policies that yield the desired change in the three system parameters (PNP specialization rate, exam passing rate, and enrollment sizes) requires significant financial investment in the marketing, recruitment and education of PNPs. For example, monetary incentives during education (e.g. scholarships) may not be sufficient for increasing the PNP specialization rate from 4.9% to 8.9%. Workplace incentives, such as pay increases, may be necessary to draw highly qualified and motivated students into the PNP field. The average annual salary for family NPs is $91,450 while the average salary for PNPs is $88,562.[25] Reducing this pay differential could lead to increased specialization in pediatric care. The financial burden of improving the average PNP salary is on employers and the medical system at large, while the PNP master's programs benefit from the increased enrollment, at no expense. Similarly, if educational programs offer scholarships to increase the specialization rate and expand their facilities and hire more faculty members to accommodate more students, employers of those graduating students benefit at no expense. The relationship between the education system and the workplace necessitates a joint effort, with investment from both entities, to effectively resolve the forecasted PNP shortage.

Study Limitations: Our estimate of annual demand growth was based upon the observed average annual percentage growth in the number of employed PNPs in the United States between 2009 and 2013. We assumed that this percentage growth will be constant in the future and drives when self-sufficiency can be reached. Due to the uncertainty of this demand growth as well as other model parameters, we have performed extensive sensitivity analysis around our estimate. Furthermore, we model the aggregate PNP workforce in the United States. Further insights would be gained if specific roles of PNPs were examined or if we considered other healthcare

professionals, such as physician assistants, as possible sources to satisfy PNP demand. Our model also does not consider the particular productivity of PNPs. Future research is needed to study how specific roles and productivity of PNPs would impact the forecasted shortage of PNPs. Our model also assumes annual attrition rates are equal for all PNPs and RNs, regardless of age. Future research will require expanding the model to include age-based attrition distributions.

Our model assumes that demand for PNPs can only be satisfied by employed PNPs. The majority of PNPs in primary and subspecialty care perform most general practice roles, including the development of treatment plans as well as assessing and diagnosing patients.[29] However, the roles of PNPs may be complimented or substituted by other pediatric health care professionals, e.g. pediatric physician assistants. Due to their training and current roles in the hospital setting, nurse practitioners and physician assistants have both been identified as a potential solution for offsetting the forecasted physician shortage and increasing access to care.[30] Future research shall investigate the interaction between these pediatric health care professionals in satisfying demand for pediatric services. Neonatal nurse practitioners are also a concern and will be the focus of a future project.

Other factors may also impact the supply of PNPs in the workforce. These include longer education time and substitution of PNPs by physician assistants or pediatricians. Future research shall investigate the effects of such system changes on the forecasted PNP shortage.

Conclusion

In conclusion, we have developed a new method for combining optimal admission decisions with forecasts of PNP supply and demand to evaluate the PNP shortage over the next quarter century under the best-case scenario. We found that the best-case scenario for the current system will be incapable of satisfying the growing demand for PNPs. Sensitivity analysis of our model revealed three policy interventions to reduce PNP shortages and the expected number of years required until the system is self-sufficient: increases in PNP specialization rates, increases in PNP certification exam passing rates, and increases in the potential annual growth rate of enrollment sizes for PNP master's programs. Without policy interventions, such as those analyzed in this paper, the PNP shortage is expected to remain for the next 13 years in the best-case scenario. However, by improving the PNP education and workforce system, this forecasted shortage can be reduced to 5 years. Given the important role of PNPs in the primary and subspecialty care of pediatric patients, a reduction in the shortage of PNPs can improve access to pediatric care for the growing pediatric population with complex and chronic diseases.

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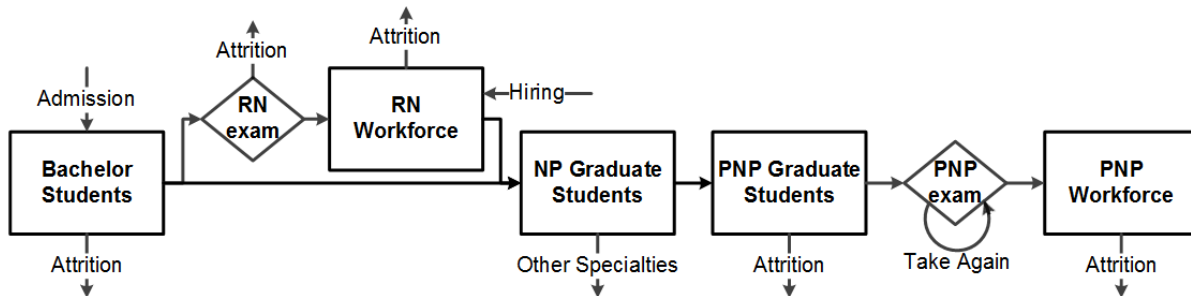**Figure 1:** Attrition is defined as the annual percentage of a stage's population leaving the system, e.g. the annual percentage of nursing baccalaureate students dropping out of the program.
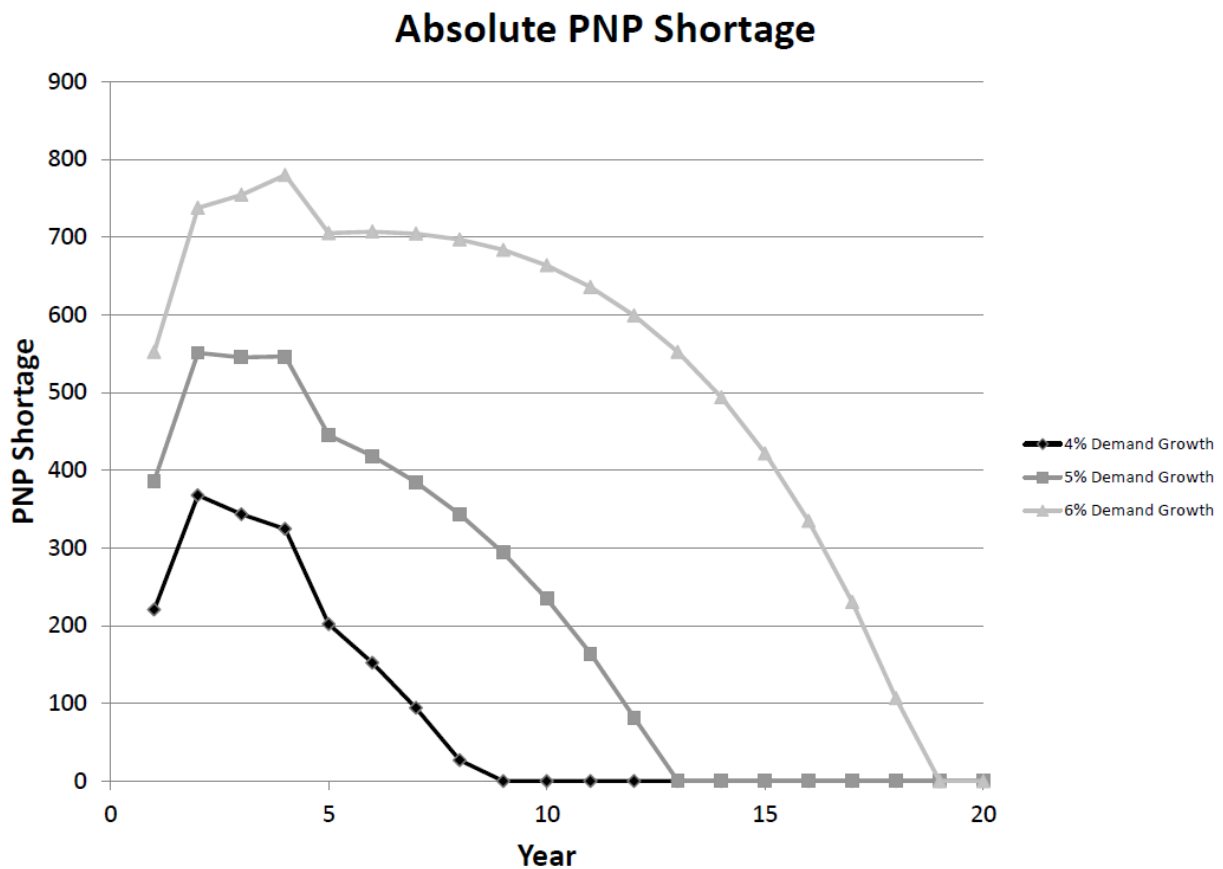

Figure 2: Annual absolute PNP shortage under three assumptions on annual PNP demand growth (%): (1) 4% growth per year, (2) 5% growth per year (baseline); and (3) 6% growth per year.
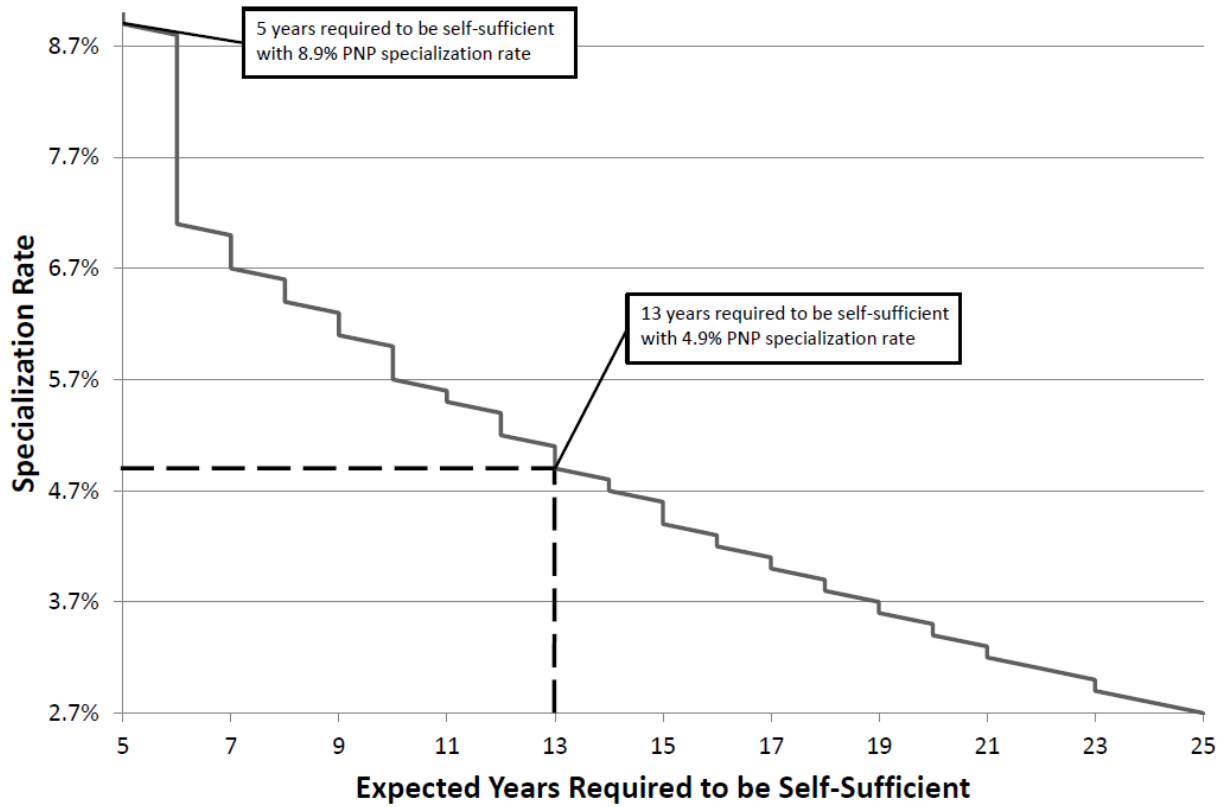
Figure 3: The PNP specialization rate is the percentage of NP master's students who choose to study pediatrics as their nursing specialty. Expected years required to be self-sufficient is defined as the minimum number of years until the system experiences no shortages of PNPs under the best-case scenario.
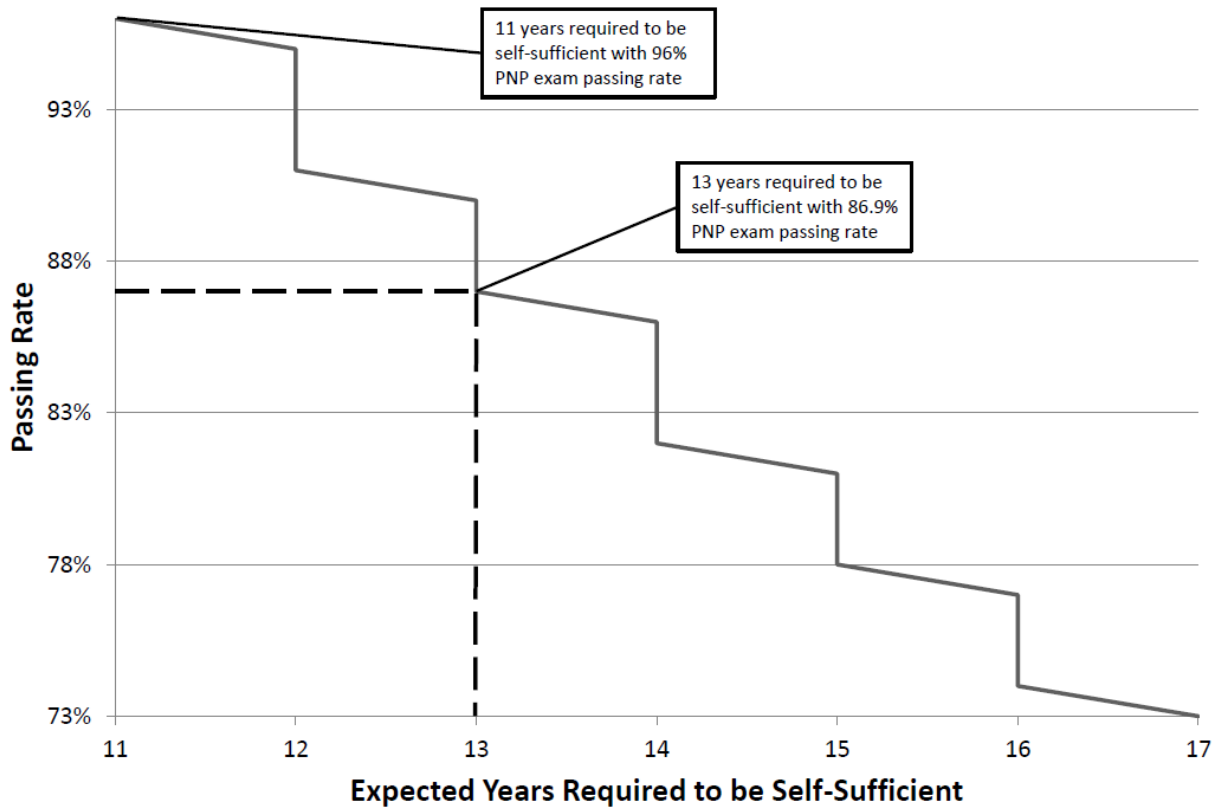
PNP Exam Passing Rate

Figure 4: PNP certification exam passing rate is the percentage of PNP graduate students who pass the PNP certification exam in their state upon graduation. Expected years required to be self-sufficient is defined as the minimum number of years until the system experiences no shortages of PNPs under the best-case scenario.
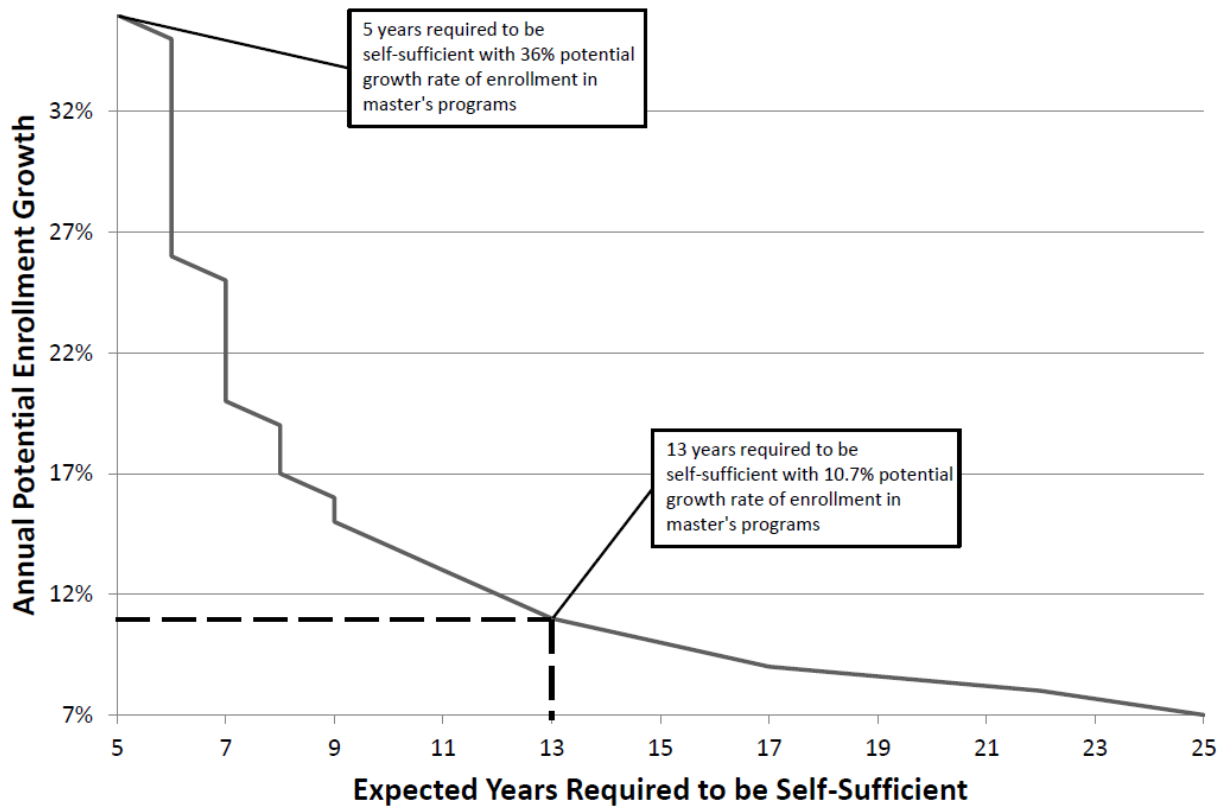
Figure 5: The potential growth rate of master's programs is the maximum annual increase in PNP master's program enrollment. Expected years required to be self-sufficient is defined as the minimum number of years until the system experiences no shortages of PNPs under the best-case scenario.

Parameter	Value	Source
Initial Number of Students Enrolled in Baccalaureate Nursing Programs	299,118	American Association of Colleges in Nursing Enrollment Data[18]
Initial Number of Students Enrolled in PNP Master's Programs	2,766	American Association of Colleges in Nursing[18]
Initial RN Workforce Size	2,763,000	American Association of Colleges in Nursing Shortage Fact Sheet[23]
Initial PNP Workforce Size	16,584	National Association of Pediatric Nurse Practitioners[24]
RN Annual Attrition Rate	3%	National Sample Survey of Registered Nurses[20]
PNP Annual Attrition Rate	1.5%	Pediatric Nursing Certification Board Recertification Data[19]
Proportion of Full Time/Part Time Traditional Undergraduate Nursing Students	90.8%/9.2%	American Association of Colleges in Nursing Enrollment Data[18]
Proportion of Full Time/Part Time RN-Baccalaureate Undergraduate Nursing Students	32.7%/67.3%	American Association of Colleges in Nursing Enrollment Data[18]
Proportion of Full Time/Part Time PNP Master's Students	38.2%/61.8%	American Association of Colleges in Nursing Enrollment Data[18]
Maximum PNP Master's Program Enrollment Growth Rate	10.7%	American Association of Colleges in Nursing Enrollment Data[18]
RN Exam Passing Rate	92.21%	National Council of State Boards of Nursing[21]
PNP Exam Passing Rate	86.9%	Pediatric Nursing Certification Board[22]
NP Specialization Rate	52.1%	American Association of Colleges in Nursing Enrollment Data[18]
PNP Specialization Rate	4.9%	American Association of Colleges in Nursing Enrollment Data[18]
PNP Annual Demand Growth	5%	National Association of Pediatric Nurse Practitioners[24,26]

Table 1: Base-case estimates for the model inputs.