



Center *for* Rural Health

Projection of North Dakota Physicians 2010–2040



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Table of Contents

Summary1

Background2

 Population Projection2

 Physician Projection.....3

Population Projection Model.....5

Physician Projection Model9

Limitations of the Given Projection Models15

The Oil Patch.....15

Conclusion17

References19

Appendix A: Calculations for Population Projections20

Appendix B: Calculations for Physician Projections24

List of Tables

1. Projected physicians per 10,000 persons in North Dakota for low, stable, and high population projections for baseline and additional medical school and residency position scenarios13

List of Figures

1. Model for population projection from 2010 to 20156

2. Projected population in North Dakota with low and high estimates from 2010 to 2040.....7

3. Projected population in North Dakota by age groups for 2010 to 20408

4. Model for physician projection from 2010 to 2015.....10

5. Alternate scenarios for North Dakota physician projection from 2010 to 2040 with population projection underlay.....12

6. Projected rates of North Dakota physicians with current and double the additions to the medical school and residency program for stable and maximum expected populations14

7. Projected rates of North Dakota oil patch persons to physicians with current, high, adding 250,000 and adding 500,000 population17

SUMMARY

The purpose of this report is to describe a projection of both the population of North Dakota and physicians in North Dakota. It allows for the user to alter parameters such as number of medical school graduates to see how this affects projections of the future. Both actual numbers and rates of physicians per 10,000 people are reported.

The projection of North Dakota (ND) population was based on separate models for males and females because of differing rates of survival and births. Projections from these models were based on survival rates, birth rates, and migration rates while adjusting for age. Total population projections were created by adding the male and female projections. The population in North Dakota in 2010 was 672,591 and was projected to increase to 682,969 by 2040 (the low estimate was 620,078 and the high estimate was 751,089).

Physician population projection in North Dakota was estimated by identifying two major categories of physicians: United States medical school graduates (USMGs, which also includes Canada) and international medical school graduates (IMGs). These two populations were projected separately because of differences in the availability of historical data. Projections of the existing USMG population were based on survival, migration, retirement rates, and newly-graduated physician rates. Projections of the IMG population were based on the historical rate of foreign physicians compared to USMGs. USMG and IMG projections were adjusted for age. The total physician projection was created by adding the USMG and IMG projections. Using these methods, we project that the number of physicians in North Dakota in 2010 (1,432) will reach a high of 1,508 in 2015, and then decrease to 1,359 in 2040.

BACKGROUND

Population Projection

The baseline population data used for this model are from the United States Census Bureau's 2010 census (USCB, 2010), the most current, comprehensive population data available. Population is broken down by sex and into five-year age cohorts. Males and females are projected separately to facilitate the usage of a fertility model and also to account for the difference in survival rates between males and females (National Center for Health Statistics [NCHS], 1999). Five-year age cohorts (18 different cohorts beginning with "0 – 4" and culminating with "85 and older") were used in order to be consistent with the projection time span. Five-year cohorts are also optimal for fertility projections which assume that accurate fertility can be calculated for females age 15-45 (United States Department of Health and Human Services [USDHHS], 2009). The population aged 85 and greater was aggregated into a single cohort because of their relatively small number and similar mortality rates over age 85 (NCHS, 1999).

Historical survival (NCHS, 1999), fertility (USDHHS, 2009), and migration rates were held as constant throughout the projections; any significant changes in migration patterns are not shown in these models. These values can be altered in the model, however, the 95% confidence interval employed in estimating the low and high values for populations should take into account reasonable future variations in these values. Extreme variations, such as those found in the oil patch of west and northwest North Dakota, can be shown independently. This model is capable of projecting the population of the state as a whole, as well as in four distinct regions (northeast, northwest, southeast, and southwest). A statewide projection is capable of

providing a comprehensive picture, while a regional level projection is capable of providing additional projection scenarios caused by regional population variations.

Physician Projection

The baseline physician population data used for this model is taken from the American Medical Association (AMA) physician master file (Medical Marketing Service, 2011). These survey data are broken out into USMGs and IMGs to account for projection variations and then added together to provide a total projection. Five-year age cohorts were used to provide consistent time frames with the population projection time span. USMG projections were estimated by using survival (NCHS, 1999), migration, and retirement rates, then adding the proportions of medical school and residency graduates from North Dakota and other US medical schools to the model. IMGs have less historical-trend data and are influenced by circumstances that cannot be controlled for within this model because of the large number of countries that supply IMGs as well as federal legislation that governs their presence in the U.S. Thus, IMG projections are based on historical proportions of IMGs in North Dakota.

The more robust data set available for USMGs allows for greater flexibility with projection modeling. A number of factors, including new physicians (medical school positions, residency positions, and other new USMGs), retirement and migration rates of current USMG physicians, and the IMG to USMG ratio, can be altered in the model to determine how they influence the final projections. Similar to the population projection, the physician projection is capable of projecting the physician population for North Dakota as a whole, or by four regions within the state. A statewide physician projection allows for a comprehensive physician-to-population projection, while a regional-level physician projection is capable of providing

projection scenarios that are influenced by variations including regional population. This model can also be implemented for specific types of physicians, e.g., primary care or psychiatry if their numbers are large enough to foster a stable and reliable model.

POPULATION PROJECTION MODEL

The population was estimated for males and females separately. Similar models were used for both groups and adjusted for age. Low and high estimates of the combined numbers were obtained through use of 95% confidence intervals. The model used survival rates, birth rates (adjusted according to age rates of females in the state), and migration rates. Detailed equations and example spreadsheets used to calculate these values are in Appendix A.

Figure 1 shows the model applied to males and females from 2010 census data (USCB, 2010), then combined for the total projected population in 2015. In 2010, the male population in North Dakota was 339,864. After adjusting for survival (NCHS, 1999), it dropped to 320,945. An estimated 24,570 births were added increasing the estimated population to 352,546 (USDHHS, 2009). Migration rates were applied, giving an estimated male population in North Dakota for 2015 as 340,732. Female population was estimated to increase from 332,727 in 2010 to 333,577 in 2015. The total estimated population in 2015 was 674,309, a slight (0.3%) increase from 672,591 in 2010.

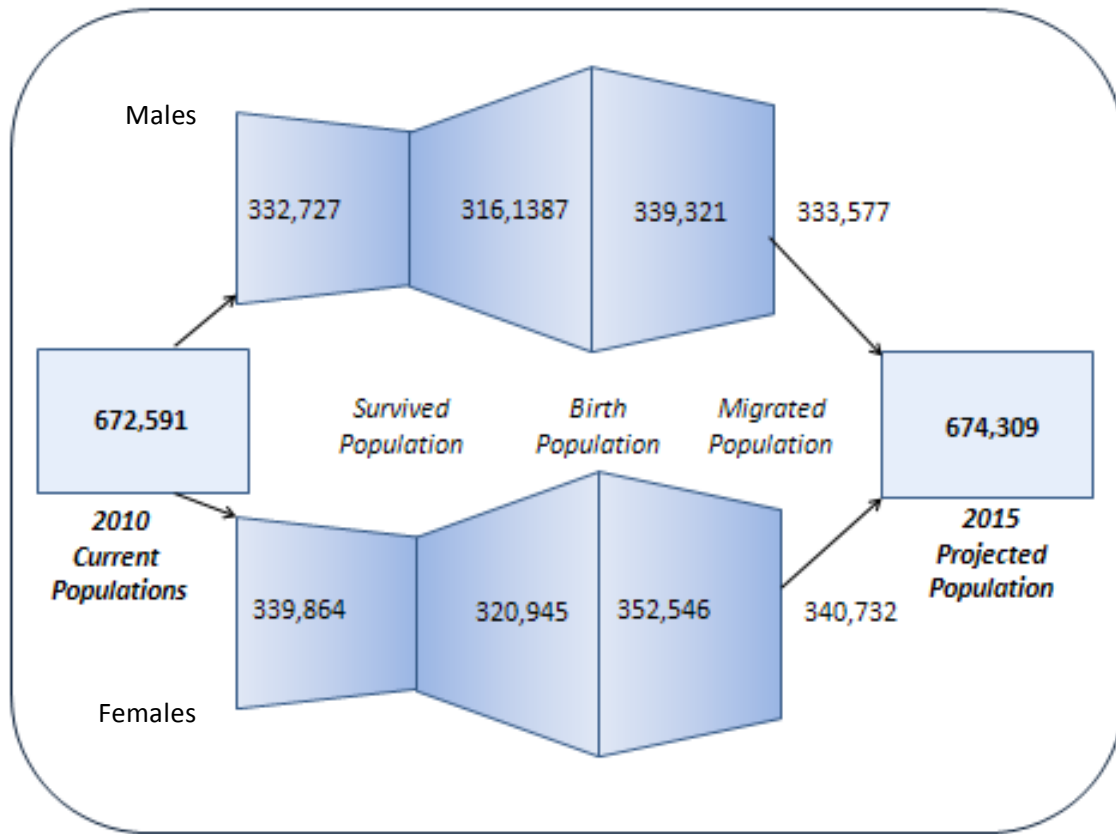


Figure 1. Model for population projection from 2010 to 2015.

Figure 2 shows the projected population with low and high estimates from 2010 to 2040. There is an expected increase of 10,378 people (1.4% increase) in North Dakota during this time span, though the population could decrease by 52,513, (-7.8% decrease) or increase by 78,498 (11.7% increase).

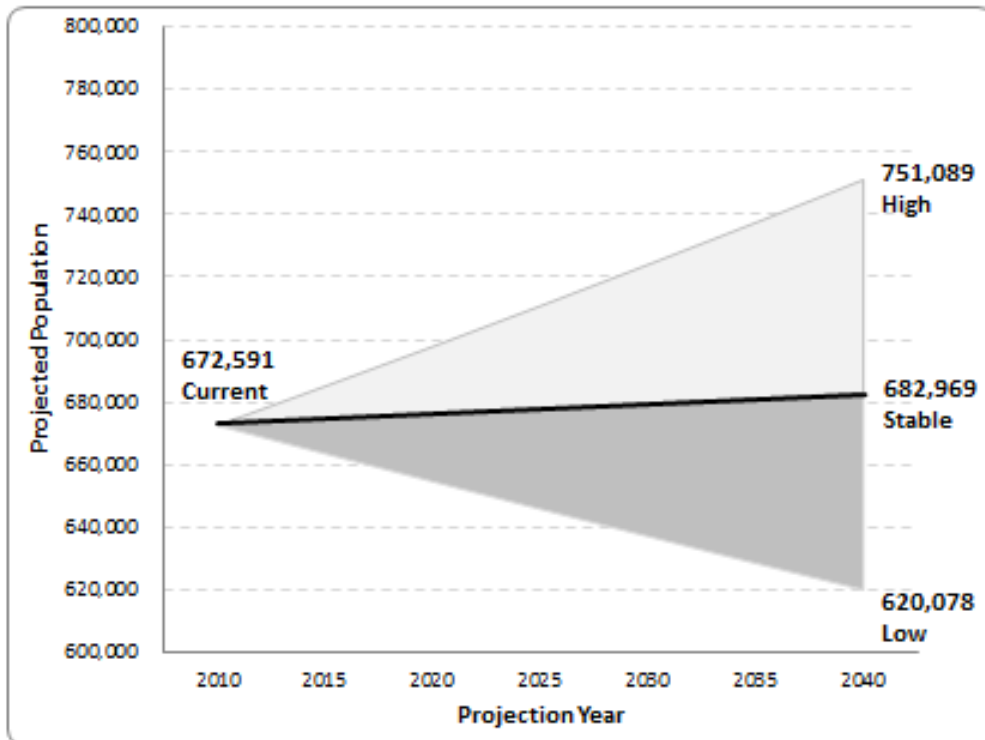


Figure 2. Projected population in North Dakota with low and high estimates from 2010 to 2040.

Figure 3 shows the variability within each age group. The young (0 – 19, green line) shows a projected increase (8.8%). The population of young adults (20 – 39, red line) is projected to decrease after 2025 (-10.9%). The older adult population (40 – 59, blue line) shows an initial projected decrease, but then increases over time (0.8 %). The population of the oldest residents (60 and older, grey line) is projected to increase quickly and then remain fairly steady over time (10.6%).

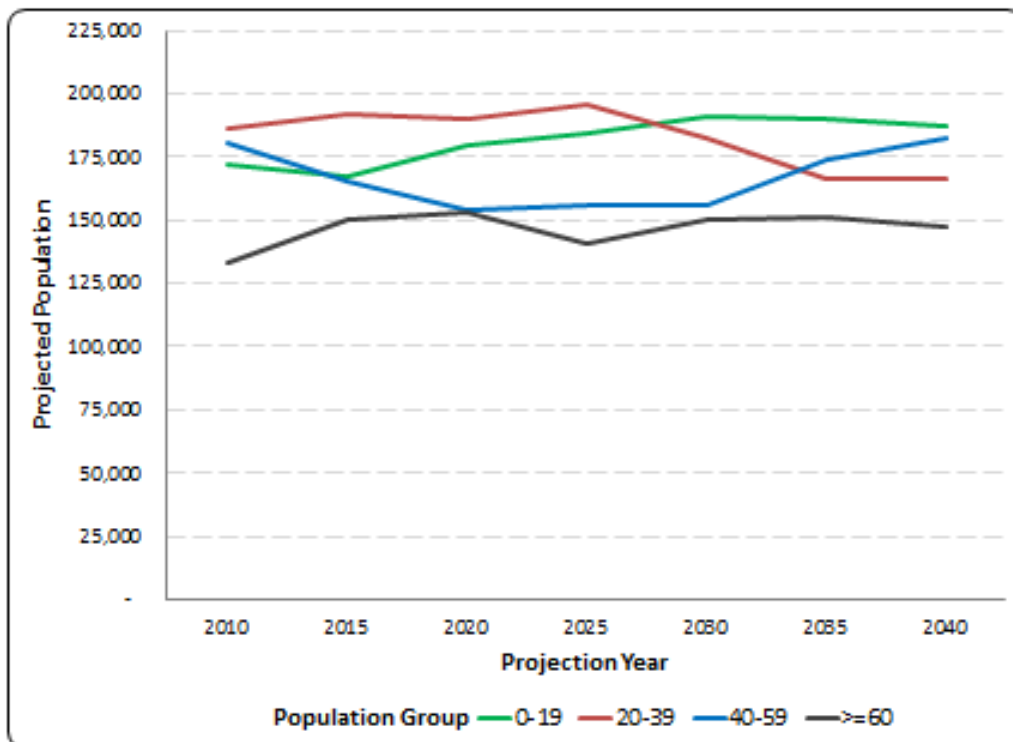


Figure 3. Projected population in North Dakota by age groups for 2010 to 2040.

PHYSICIAN PROJECTION MODEL

Two main groups of physicians, USMGs and IMGs, were projected separately and then combined to create an overall projection by 5-year time frames. The USMG projection used mortality rates (NCHS, 1999), migration rates, and retirement rates historical to North Dakota physicians, and anticipated new physicians in five-year age cohorts to project numbers of future North Dakota physicians. The IMG projection used the historical trend of the ratio of IMG physicians to total physician population combined with historical IMG age-cohort distribution to project the numbers of IMG physicians.

Figure 4 shows the model using the current 2010 number of USMG physicians (N = 1,101) to project the number of 2015 physicians (N = 1,508). When the total of 1,101 current USMG physicians is adjusted forward to the projected number who will have survived after 5 years, their total decreases to 1,027 (NCHS, 1999). When adjusting further according to both migration (in or out of North Dakota relative to 5 year age groups) and retirement rates for physicians 65 and older, the number decreases to 1,010. The number of newly-graduated physicians (distributed by age) from the University of North Dakota School of Medicine, residency, and US medical schools is then added, increasing the projected total to 1,131. The projected number of IMGs, calculated separately relative to the historical proportion by age, increased from 331 to 377. This was added to the projected number of USMG physicians, increasing the final projected number of physicians in North Dakota to 1,508 (5.3% increase). Appendix B provides the details of the equations used and example spreadsheets for these calculations.

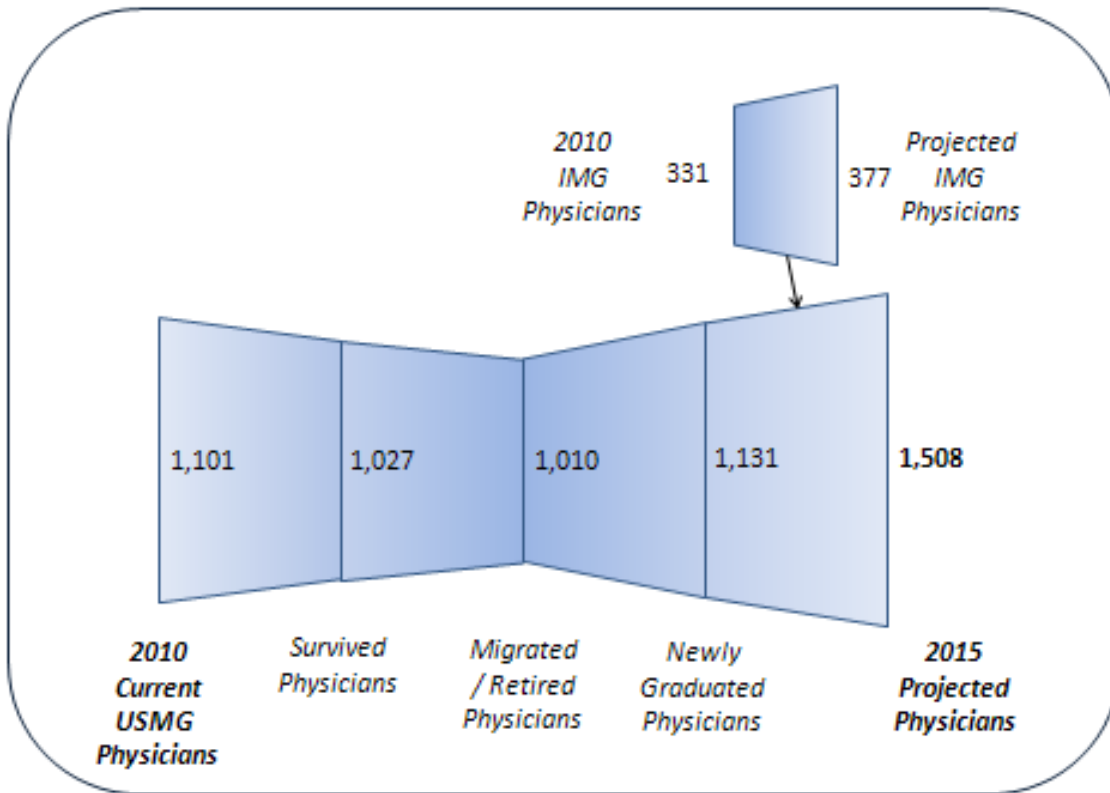


Figure 4. Model for physician projection from 2010 to 2015.

A number of factors can be altered in this projection model to determine how they influence the final projection. Migration rates are based on historical data, but if a strong recruitment of current physicians from out of state is planned, that rate could increase. Retirement rates (42% for 65 to 69 and 46% for those 70 and older) can also be adjusted. The number of first-year residency, first-year medical school, and total first-year medical school and residency positions can be adjusted within the model to determine how increasing positions over time will influence the future workforce supply. For example, if out-of-state demand for physicians increases (perhaps as a consequence of the Affordable Care Act), the model can be adjusted to reflect an increased migration out of North Dakota and decreased migration into

North Dakota. Further, if a law is changed allowing IMGs easier access to practice in the US, those numbers can also be adjusted appropriately.

Figure 5 illustrates three possible ways to alternate the physician projection. The first scenario (solid red line or 'Baseline') is the projection if current trends remain stable, with no additional increases in medical school or residency positions, and no increase in the numbers of either IMGs or out-of-state physicians. The second scenario (solid blue line or 'Baseline + MS, Res) is the projection if medical school and residency positions increase at a stable rate every year from 2020-2040 (14.55% increase in medical school positions, 18.75% increase in residency positions). The third scenario (dashed red line 'Baseline + IMG') is the projection if IMG numbers increase to represent 30% of all physicians in North Dakota (currently 25%). The fourth scenario (dashed blue line 'Baseline + MS, Res, IMG') combines an increase in medical school and residency positions with an increase in IMG numbers. The grey area underlying these projections represents the North Dakota population projections from Figure 2 as the grey area.

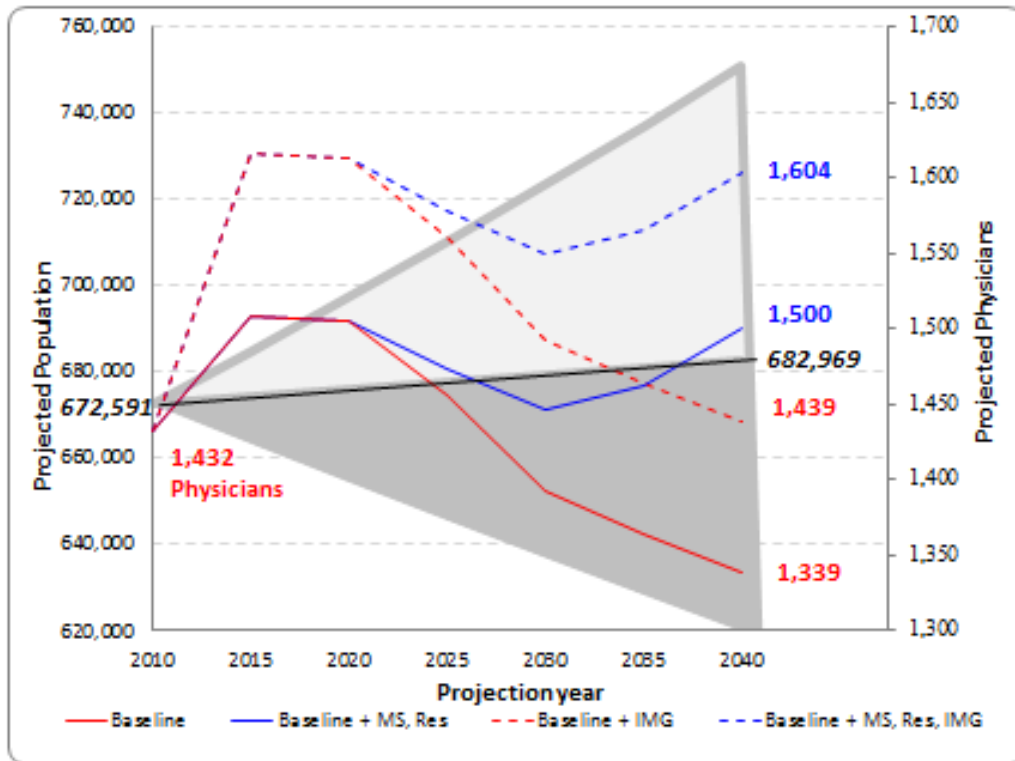


Figure 5. Alternate scenarios for North Dakota physician projection from 2010 to 2040 with population projection underlay.

Table 1 shows the rates of physicians per 10,000 persons in North Dakota according to both the baseline projection and the projection where medical school and residency positions are added. When there is no increase in the rate physicians are added or removed from the model (baseline), the rate will drop from 21.3 to 19.6 physicians per 10,000 persons by 2040. If new positions are added to the medical school and residency programs (baseline + medical school and residency), the rate of physicians per 10,000 persons increases slightly from 21.3 to 22 in 2040. The current rate (21.3) is below the current national rate of 25.7 physicians per 10,000 persons (NCHS, 2011). It is also lower than Minnesota's rate of 27.0, but near the rate of South Dakota (21.8) and Montana (21.9) (NCHS 2011).

	<i>Baseline</i>			<i>Baseline + Med School and Residency</i>		
	<i>Low</i>	<i>Stable</i>	<i>High</i>	<i>Low</i>	<i>Stable</i>	<i>High</i>
2010	21.3	21.3	21.3	21.3	21.3	21.3
2015	22.7	22.4	22.0	22.7	22.4	22.0
2020	23.0	22.3	21.6	23.0	22.3	21.6
2025	22.5	21.5	20.5	22.8	21.7	20.7
2030	21.9	20.5	19.2	22.7	21.3	20.0
2035	21.7	20.0	18.5	23.3	21.5	19.8
2040	21.6	19.6	17.8	24.2	22.0	20.0

Table 1. Projected physicians per 10,000 persons in North Dakota for low, stable, and high population projections for baseline and additional medical school and residency position scenarios.

As projection rates can be changed based on changes in population as well as various inputs (e.g., number of new graduates), Figure 6 gives an example of the rate of physicians per 10,000 persons in North Dakota based on the current situation where eight medical school positions and nine residency positions were added (solid red line) and twice as many positions were added (solid blue line). Both of these lines assume a stable population growth (current 672,591 increasing to 682,969 by 2040). The dashed lines represent their counterparts where the population is growing at the maximum projected rate (currently 672,591 increasing to 751,089 by 2040).

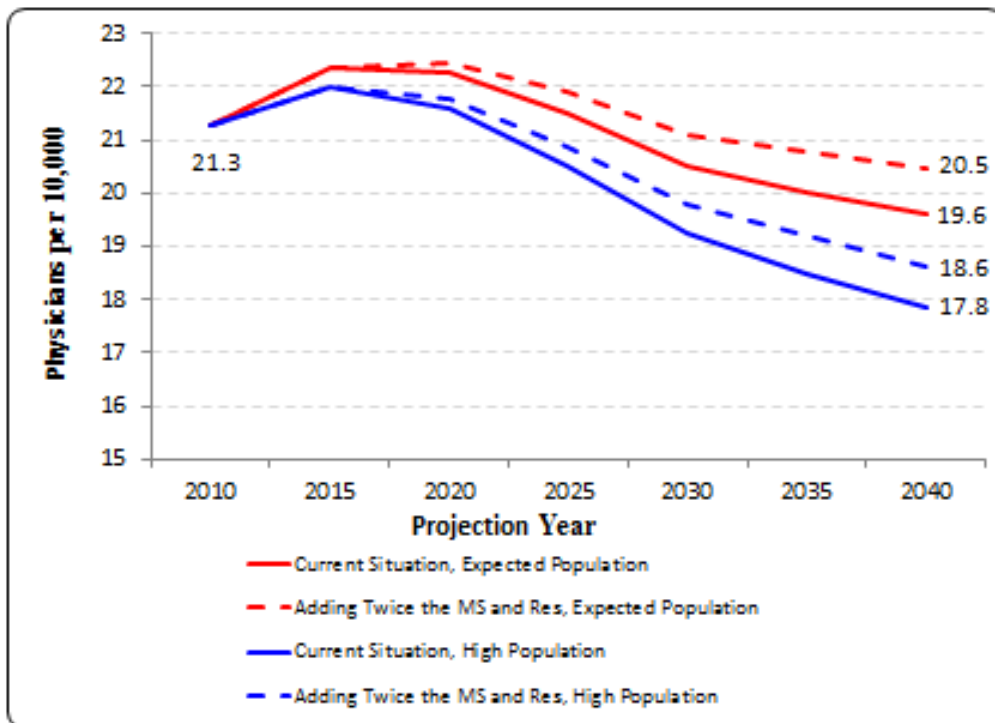


Figure 6. Projected rates of North Dakota physicians with current and double the additions to the medical school and residency program for stable and maximum expected populations.

With stable population (solid red line), the projected rate of physicians per 10,000 residents will increase until 2015, then decrease back to the current level (21.3) by 2026. If twice as many medical student and residency positions are added, the projected rate will increase and remain higher than the current level until it begins to decrease in 2029. If the population grows at the maximum expected rate, the physician rate will drop back down to the current rate by 2021.

LIMITATIONS OF THE GIVEN PROJECTION MODELS

This report only gives a few examples of how the projection model can be affected by several variables. The current population projections are based on historical trends. Though these trends do include previous large influxes of population, such as happened during the oil boom of the 1970's, the current oil boom may surpass those numbers. Other factors, such as drought, can lead to an outmigration. Historical trends account for much of these variations and the 95% confidence intervals allows room for variation in the population projections; however, this model can be easily run with higher future populations. Regionalization of North Dakota can also be used to accommodate different populations and different provider supplies within areas of the state. Variables affecting the in- and outmigration of physicians can also be adjusted. Specifically: the number of medical school and residency positions in North Dakota, rules regarding IMGs working in the US, changes in state demands for physicians, and federal and state payment levels. This projection model is, therefore, general in that the variables in the model can be adjusted and it can be applied to other health care professions such as physician assistants or nurses as well as specialty areas such as family medicine, psychiatry, or surgery.

The Oil Patch

The projections shown do not take into account any regional variations in either population or physician supply. The oil patch in northwest North Dakota is a specific area of concern. It has been estimated that the area has seen a large influx of adults (especially male) and children, and an outmigration of elderly residents. Although the exact population numbers are not known, they are likely much higher than the historical trends. The number of physicians

working in this area may also be increasing, but not likely as much as the population. Figure 7 shows estimates of the ratio of population to physicians in the oil patch area (shown on the map insert).

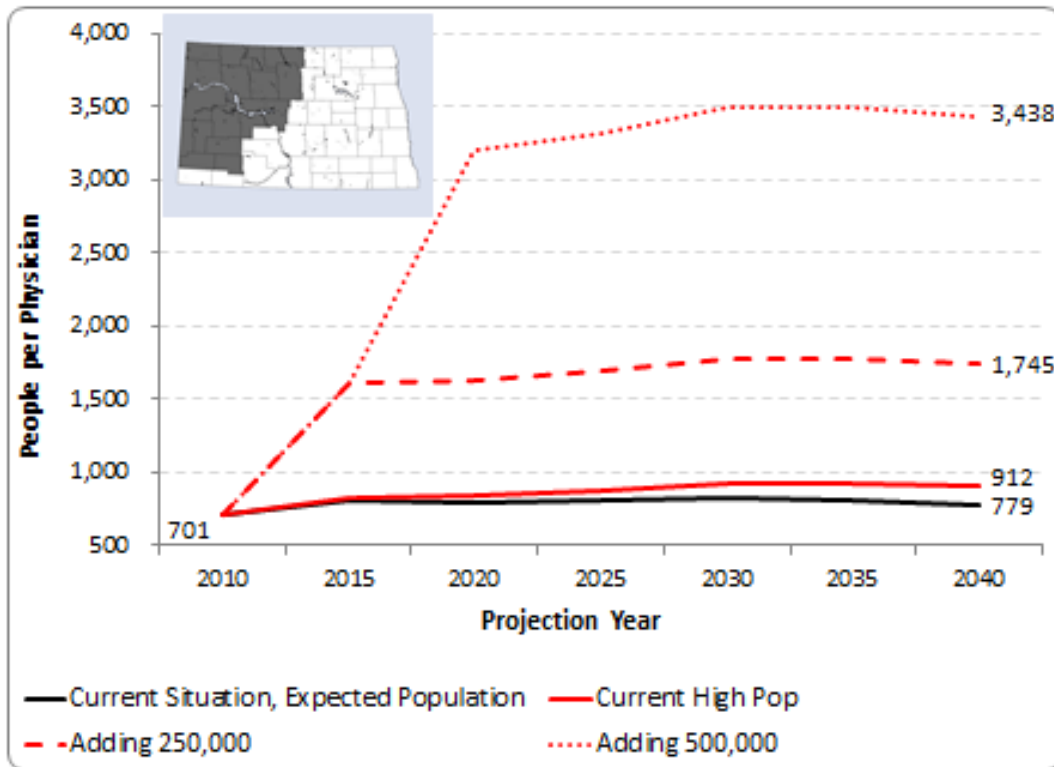


Figure 7. Projected rates of North Dakota oil patch persons to physicians with current, high, adding 250,000 and adding 500,000 population.

Two different population increases are represented: one for 250,000 more people and another for 500,000 people. The increase in number of physicians represented is the historical trend. The largest increase is expected for the first 10 years; the increase then lessens as the expected oil wells are drilled and the need for workers decreases. The projected rate of people per physicians more than doubles if the population increases to 250,000 (779 to 1,745) and increases fivefold if the population increases by 500,000 (779 to 3,438).

CONCLUSION

The population in North Dakota is gradually increasing over time. Unanticipated events such as economic changes and natural disasters presents migration variability and uncertainty. North Dakota's population is becoming older overall, but different geographical regions are showing dissimilar trends and have the potential to vary greatly from their historical trends. The general trend, however, is for the population to increase by 10,378 in the next 30 years.

Physician projections show a gradual increase, and then decrease as older physicians retire from practice. This decrease will begin to take effect within ten years (solid red line, Figure 5). Steps can be taken to avoid this decrease, such as recruiting more physicians from out of state or out of the country, or increasing the numbers of North Dakota medical school graduates and residency positions.

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APPENDIX A

Calculations for population projections

Males and Females***Survival Factor***

<Raw Population Estimate in an Age Group> = <Current Population in Sex and Age Group>*<Survival Rate for them>

The first equation creates a raw estimate of the number of people in a specific age group within the sex cohort by adjusting the population by the mortality rate. These mortality rates are based on the North Dakota life table for 1989-1991. Mortality is determined by dividing the number of survived persons over five years by the number of persons alive at the beginning of the same time frame. This value is expressed as a rate and is used to estimate how many people of a similar age will survive. A sub-step of this equation is the birth factor, which calculates the new population age 0-4. The following table is for females in North Dakota.

Age Group	Females 2010	Survival Rate	Age Group	Survived
0-4	21,774	0.998233	5-9	21,736
5-9	19,556	0.999159	10-14	19,540
10-14	19,429	0.998829	15-19	19,406
15-19	22,848	0.998101	20-24	22,805
20-24	27,426	0.997943	25-29	27,370
25-29	23,145	0.997902	30-34	23,096
30-34	19,288	0.997370	35-39	19,237
35-39	17,856	0.994390	40-44	17,756
40-44	18,580	0.990008	45-49	18,394
45-49	22,919	0.986080	50-54	22,600
50-54	24,971	0.977584	55-59	24,411
55-59	22,312	0.964774	60-64	21,526
60-64	17,573	0.951712	65-69	16,724
65-69	13,126	0.925536	70-74	12,149
70-74	11,210	0.885951	75-79	9,932
75-79	10,243	0.814360	80-84	8,341
80-84	9,234	0.693756	85+	11,115
85+	11,237	0.419057		
Totals	332,727			316,138

Birth Factor

$\langle \text{New Population age 0-4} \rangle = \langle \text{Survived Females age 15-54} \rangle * \langle \text{Fertility Rates for them} \rangle * \langle \text{SexRatio for live births} \rangle * \langle \text{Survival for age 0-4} \rangle$

The birth factor is used to estimate the number of babies born in North Dakota. It takes the number of survived females age 15-54, fertility rates for each five year cohort, and a sex ratio to determine the new population age 0-4. The number of surviving females is first multiplied by the fertility rate for each age cohort to project the numbers of babies. These babies are then separated out into male and female by adjusting for the sex ratio. The numbers of male and female babies are then adjusted for the mortality rate to project the number of surviving babies age 0-4.

Age Cohort 2010	Observed Females 2010	Age Cohort 2015	Survived Females 2015	Average Population	Five Year Fertility Rates	Projected Babies Five Years
10-14	19,429	15-19	19,406	19,418	0.0000	-
15-19	22,848	20-24	22,805	22,826	0.1326	3,027
20-24	27,426	25-29	27,370	27,398	0.4168	11,418
25-29	23,145	30-34	23,096	23,121	0.7941	18,360
30-34	19,288	35-39	19,237	19,263	0.5478	10,552
35-39	17,856	40-44	17,756	17,806	0.2120	3,774
40-44	18,580	45-49	18,394	18,487	0.0385	712
45-49	22,919	50-54	22,600	22,759	0.0000	-
Totals	171,491		170,664	171,078		47,843

Sex Ratio	106
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	Projected Babies Five Years	0-4 Year Old Survival Rate	Survivors
Males	24,618	0.998035	24,570
Females	23,225	0.998233	23,184

Current Migration Factor

$\langle \text{Migration Adjustment Factor Age Group} \rangle = \langle \text{Raw Population Estimate in Age Group} \rangle / \langle \text{Total Population Estimate for Sex} \rangle$

The second equation uses the total of the raw estimates of the population to find the proportion of people in each age group for this sex cohort. For example, there is a raw population estimate of 339,321 shown below. Of this, the 23,184 survivors in the 0-4 category represent 6.83%. This percentage of each age group (based on survival estimates) can be used

to adjust the numbers for the age groups in the estimated population. This controls for the most recent migration patterns.

Age Group	Population Estimate	Migration Adjustment
0-4	23,184	6.83%
5-9	21,736	6.41%
10-14	19,540	5.76%
15-19	19,406	5.72%
20-24	22,805	6.72%
25-29	27,370	8.07%
30-34	23,096	6.81%
35-39	19,237	5.67%
40-44	17,756	5.23%
45-49	18,394	5.42%
50-54	22,600	6.66%
55-59	24,411	7.19%
60-64	21,526	6.34%
65-69	16,724	4.93%
70-74	12,149	3.58%
75-79	9,932	2.93%
80-84	8,341	2.46%
85+	11,115	3.28%
Total	339,321	

Projected Population for Sex Cohort

<Estimated Projected Population in Age Group for Sex> = <Migration Adjustment Factor Age Group> * <Estimated Total Population for Sex>

The third equation uses the migration adjustment factors on the estimated total population for each sex to estimate the projected population. The estimated total population is the current total population (332,727 in 2010) plus change based on average migration changes from the past 80 years (0.26% increase).

Age Group	Migration Adjustment	Projected Population
0-4	6.83%	22,791
5-9	6.41%	21,368
10-14	5.76%	19,209
15-19	5.72%	19,078
20-24	6.72%	22,419
25-29	8.07%	26,906
30-34	6.81%	22,705
35-39	5.67%	18,912
40-44	5.23%	17,455
45-49	5.42%	18,083
50-54	6.66%	22,217
55-59	7.19%	23,998
60-64	6.34%	21,162
65-69	4.93%	16,441
70-74	3.58%	11,943
75-79	2.93%	9,763
80-84	2.46%	8,200
85+	3.28%	10,927
Estimated Total Population		333,577

Projected populations for each sex cohort within age groups are then added together to obtain the total population projection for each age group in North Dakota.

APPENDIX B

Calculations for Physician Projections

USMG Physicians***Survival Factor***

$$\langle \text{USMG Survived Estimate in Age Group} \rangle = \langle \text{USMG Current Population in Age Group} \rangle * \langle \text{Survival Rate} \rangle$$

The first equation creates a raw estimate of the number of survived USMG physicians in a specific age group by adjusting the number of USMG physicians in 2010 for mortality rates. These mortality rates are based on the North Dakota life table for 1989-1991. Mortality is determined by dividing the number of survived persons over five years by the number of persons alive at the beginning of the same time frame. This value is expressed as a rate and is used to estimate how many people of a similar age will survive.

Age Group	USMGs 2010	Survival Rate	Age Group	Survived USMGs
30-34	70	0.991200	35-39	69
35-39	108	0.988765	40-44	107
40-44	145	0.984519	45-49	143
45-49	176	0.977286	50-54	172
50-54	175	0.965379	55-59	169
55-59	192	0.948436	60-64	182
60-64	149	0.928436	65-69	138
65-69	52	0.897522	70-74	47
70-74	34			
<i>Total</i>	<i>1,101</i>		<i>Total</i>	<i>1,027</i>

Migration Factor

$$\langle \text{USMG Migrated Estimate in Age Group} \rangle = \langle \text{USMG Survived Estimate in Age Group} \rangle * \langle \text{Migration Rate for Age Group} \rangle$$

The second equation creates an estimate of USMG physicians in age groups adjusting the survived USMG numbers for migration rates. The migration rates used here are based on the historical 5-year physician trend after mortality rates are applied. The mean change over time between 5-year age cohorts was calculated as the standard for migration. Negative values (out migrations) are shown in parentheses.

Age Group	Survived USMGs	Migration/ Retirement Rate	+/-	Survived / Migrated USMGs
30-34	69	(0.01791)	(18)	51
35-39	107	0.04372	45	152
40-44	143	(0.02820)	(29)	114
45-49	172	0.02674	27	199
50-54	169	(0.01936)	(20)	149
55-59	182	0.00893	9	191
60-64	138	(0.02855)	(29)	109
65-69	47	(0.00226)	(2)	44
<i>Total</i>	<i>1,027</i>		<i>Total</i>	<i>1,010</i>

Newly Graduated Physicians Factor

<New USMG Physicians> = <Total First Year Med School Positions>*<Med School Retention> + <Total First Year Resident Positions>*<Resident Retention> + <Total First Year Med School and Residency Positions>*<First Year Med School and Residency Retention> + <Other USMG Input>

The third equation calculates the number of anticipated USMG physicians based on four categories: the number of North Dakota medical school graduates, North Dakota residents, North Dakota medical school and residents, and out-of-state medical school graduates in the five-year time frame. These are adjusted for historical retention and proportion of total physicians. Historical retention is estimated using AMA data. 50% of these new physicians are attributed to the 30-34 age cohort, 30% to the 35-39 age cohort, and 20% to the 40-44 age cohort.

Projected USMG Physicians

<Projected USMGs> = <USMG Survived/Migrated Estimate in Age Group> + <New USMG Physicians in Age Group>

The fourth equation adds the survived and migrated USMG physicians in age group to the new USMG physicians in age group to create a projection of USMGs.

Age Group	Survived / Migrated USMGs	ND MS Grads	ND Res	ND MS & Res	Other USMS Grads	Projected USMGs
30-34		24	10	2	24	61
35-39	51	15	6	1	14	87
40-44	152	10	4	1	10	176
45-49	114					114
50-54	199					199
55-59	149					149
60-64	191					191
65-69	109					109
30-34	44					44
<i>Total</i>	<i>1,010</i>				<i>Total</i>	<i>1,131</i>

IMG Physicians

<Projected IMGs> = <Total USMG Estimate>/3 redistributed by the current IMG trend by age cohort.

The fifth equation takes the proportion of IMGs to total physicians and distributes them over age ranges based on historical trend. Historically, 25% of physicians have been IMGs. The total projected numbers of USMGs are divided by 3 to determine what would be 25% of the total physician projection. This total is then attributed to the age cohorts based on the current distribution trend of IMGs.

Age Group	Distribution Proportion	Projected IMGs
30-34	0.0755	28
35-39	0.1631	62
40-44	0.2085	79
45-49	0.1118	42
50-54	0.1239	47
55-59	0.0997	38
60-64	0.1269	48
65-69	0.0604	23
30-34	0.0302	11
<i>Total</i>		<i>377</i>

Projection of Physicians in North Dakota

<Projected Physicians>=<USMG Estimate in Age Group> +

The last equation adds the USMG estimate and IMG estimate to create a total estimated physician population by age group.

Age Group	Projected USMGs	Projected IMGs	Projected Physicians
30-34	61	28	89
35-39	87	62	149
40-44	176	79	255
45-49	114	42	156
50-54	199	47	246
55-59	149	38	187
60-64	191	48	239
65-69	109	23	132
70-74	44	11	56
Total	1,131	377	1,508