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EE401

Characterizing the Impact on Work Productivity in Patients With Duchenne Muscular Dystrophy and Caregivers: An Economic Analysis

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Objective

To quantify the lifetime loss of income and work years for patients with Duchenne muscular dystrophy (DMD) and their caregivers based on the natural history progression of DMD

Key Findings

DMD has a significant negative impact on work productivity and is associated with financial burdens on patients and caregivers

BACKGROUND

- DMD is a rare degenerative neuromuscular disease resulting in progressive muscle weakness, loss of functional ability, and premature death[1]
- Disease progression is associated with loss of functional independence, as patients become increasingly dependent on caregivers to manage their everyday needs[2,3]
- Caregivers can also incur substantial financial burdens due to reduced work productivity and labor force participation[4-7]
- Following patients' loss of ambulation, due to caregivers stopping work or reducing working weeks per year and working hours per week, labor market productivity is reduced substantially over time[8]

CONCLUSIONS

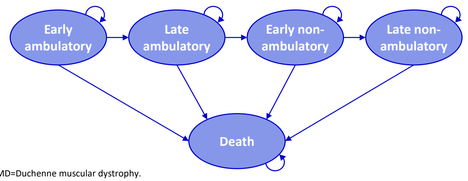
- This study estimates that patients with DMD will lose an average of 35 working years equating to ~$1.91 million in income over their lifetime relative to the general US male population; caregivers will lose ~4.4 working years, equating to ~$165,000 in income, from an average age of 32
- Scenario and sensitivity analyses suggested that work opportunity loss is driven by early disease progression and premature mortality
- These results underscore the significant negative impact on work productivity and the associated financial burden that DMD poses on patients and caregivers, which should be recognized in assessments of the disease

METHODS

Procedures

- A lifetime cost model was developed using a 5-state partitioned survival model to characterize DMD disease progression (**Figure 1**)
- Health states included early and late ambulatory, early and late non-ambulatory, and death

Figure 1. Schematic Diagram of the Partitioned Survival Model for DMD



DMD=Duchenne muscular dystrophy.

- Work productivity of patients with DMD and their caregivers was calculated and compared with that of the US general population to estimate work years and lifetime income lost (**Table 1**)
- Salaries were adjusted for annual salary growth by 2.72% and a discount rate of 3% per annum was applied to potential earnings (scan QR code for details)

Table 1. Assumptions of Workforce Participation by Health State for Patients With DMD and Their Caregivers

Health State	Patients With DMD (%)[a]			Caregivers (Hours)[b]
	Base Case	Scenario 1	Scenario 2	
Early ambulatory	100	100	100	-1.5
Late ambulatory	80	100	67	-1.5
Early non-ambulatory	20	50	33	-459.0
Late non-ambulatory	0	0	0	-809.4

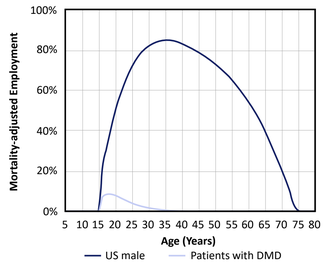
[a]Percentage workforce participation relative to age-related employment rates in the general population.
[b]Annualized loss of working hours due to informal care.[8]
DMD=Duchenne muscular dystrophy.

RESULTS

Base case

- Patients with DMD lose a total of 34.9 working years or 97.6% of their potential working years over their lifetime compared with the general US male population (0.9 vs 35.8 years) (**Figures 2a, 2b; Table 2**)
- Substantially reduced length of employment in patients with DMD results in earning 98.3% less than the average US male, equating to an estimated lifetime loss of income (LOI; discounted) of $1.9 million (**Table 2; Figure 5** [scan QR code for figure])
- From the age of 32 years, caregivers of patients with DMD lose 4.4 of their potential remaining working years over their lifetime vs the general US population (20.1 vs 24.4 years) (**Figures 3a, 3b; Table 3**)
- Caregivers of patients with DMD incur a lifetime LOI (discounted) of $165,565 on average, or 12.0% loss, vs general US population (**Table 3; Figure 6** [scan QR code for figure])

Figure 2a. US Male Population vs Patients With DMD Mortality-adjusted Employment Rates



DMD=Duchenne muscular dystrophy.

Figure 2b. Cumulative Work Years Lost in Patients With DMD

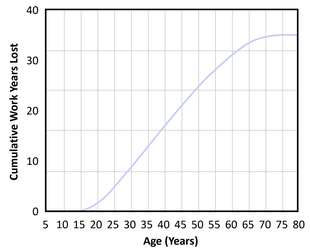


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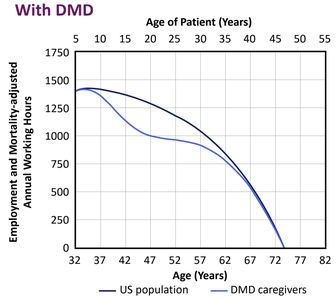
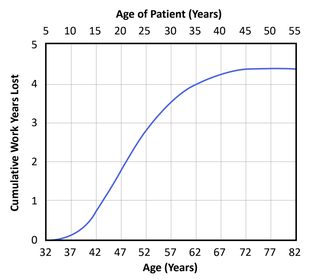
Figure 3a. Annual Working Hours for the US Population and Caregivers of Patients With DMD



DMD=Duchenne muscular dystrophy.

Figure 3b. Cumulative Work Years Lost for Caregivers of Patients With DMD



DMD=Duchenne muscular dystrophy.

Table 2. Loss of Income of Patients With DMD Compared With General US Male Population

	Patients With DMD	US Male Population[a]	Difference	Percentage Difference
Working years[b]	0.86	35.78	34.93	97.6
Income (undiscounted)	$57,355	$6,469,403	$6,412,047	99.1
Income (discounted[c])	$32,902	$1,943,462	$1,910,560	98.3

[a]Control represents US male population. [b]Working years were not discounted. [c]Discount rate is 3% per annum.
DMD=Duchenne muscular dystrophy.

Table 3. Work Productivity of Caregivers of Patients With DMD Compared With General US Population

	Caregivers	General US Population[a]	Difference	Percentage Difference
Working years[b]	20.05	24.42	4.37	17.9
Income (undiscounted)	$2,046,976	$2,325,372	$278,396	12.0
Income (discounted[c])	$1,218,359	$1,383,924	$165,565	12.0

[a]Control represents US general population (male and female). Note that lifetime income and working years are lower than the control for patients with DMD due to the caregivers and matched controls being aged 32 years when the analysis begins. [b]Working years were not discounted. [c]Discount rate is 3% per annum.
DMD=Duchenne muscular dystrophy.

Scenario and sensitivity analyses

- Results from the base case were robust to sensitivity analyses using lower and upper CIs for survival analyses (**Table 4**)
- Alternative scenarios for workforce participation for patients with DMD also had a marginal effect on the results

Table 4. Scenario and Sensitivity Analyses

Scenario	Patients With DMD		Caregivers	
	Work Years Lost	Loss of Income	Work Years Lost	Loss of Income
Base case	**34.93**	**$1,910,560**	**4.37**	**$165,565**
DMD progression: Lower CIs	35.24	$1,923,771	4.57	$176,576
DMD progression: Upper CIs	34.49	$1,891,165	4.13	$153,843
Patients with DMD work participation: Scenario 1[a]	34.12	$1,878,045	–	–
Patients with DMD work participation: Scenario 2[b]	34.67	$1,899,544	–	–
Caregiver work productivity: Female caregivers only[c]	–	–	4.37	$137,709
Caregiver work productivity: Average 1731 hours[d]	–	–	4.53	$171,332
Salary range: Lower quartile	–	$1,260,902	–	$112,992
Salary range: Upper quartile	–	$3,084,618	–	$263,219

[a]Scenario 1: 100% in early ambulatory, 100% in late ambulatory, 50% in early non-ambulatory, 0% in late non-ambulatory. [b]Scenario 2: 100% in early ambulatory, 67% in late ambulatory, 33% in early non-ambulatory, 0% in late non-ambulatory. [c]Female data used for employment rates, salary, and all-cause mortality. [d]Assumes the average hours worked per year for the US population (male and female) is the same as the Soelaeman et al.[8] control group.
DMD=Duchenne muscular dystrophy.

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1. Szabo SM, et al. *Orphanet J Rare Dis.* 2021;16:237. **2.** Yamaguchi M, et al. *Disabil Rehabil.* 2019;41:746-52. **3.** Bendixen RM, et al. *Health Qual Life Outcomes.* 2012;10:43. **4.** Labisa P, et al. *Pharmacoecon Open.* 2022;6:211-18. **5.** Flores D, et al. *Eur J Health Econ.* 2020;21:1015-23. **6.** Landfeldt E, et al. *Neurology.* 2014;83:529-36. **7.** Schreiber-Katz O, et al. *Orphanet J Rare Dis.* 2014;9:210. **8.** Soelaeman RH, et al. *Muscle Nerve.* 2021;64:717-25. **9.** McDonald CM, et al. *Lancet.* 2018;391(10119):451-61. **10.** Broomfield J, et al. *Neurology.* 2021;97:e2304-14. **11.** Passamano L, et al. *Acta Myol.* 2012;31:121-5. **12.** Paramsothy P, et al. *Neuromuscul Disord.* 2022;32:468-76. **13.** https://www.bls.gov/cps/cpsaat03.htm [Accessed Apr 28, 2023]. **14.** https://www.bls.gov/news.release/pdf/wkyeng.pdf [Accessed Apr 28, 2023]. **15.** Soim A, et al. *J Child Neurol.* 2021;36:1095-102. **16.** Osterman M, et al. Births: final data for 2020. National Vital Statistics Reports; vol 70 no 17. National Center for Health Statistics; 2022. **17.** Drummond M, et al. *Methods for Economic Evaluation of Health Care Programmes* (3rd ed). Oxford University Press; 2005. **18.** Gray A, et al. *Applied Methods of Cost-effectiveness Analysis in Health Care* (vol. 3). Oxford University Press; 2010.

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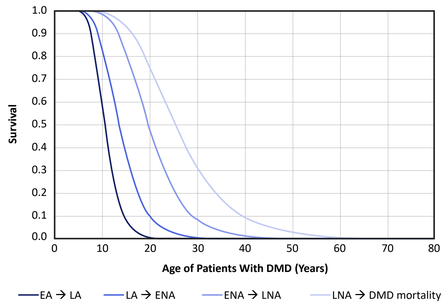
METHODOLOGY

Model framework

- Time spent in early and late ambulatory and early and late non-ambulatory health states was estimated using log-normal distributions fitted to digitally reconstructed Kaplan-Meier (KM) estimates from a prospective cohort study[9]
  - Loss of ability to stand from supine in <5 seconds was used for transition from early to late ambulatory
  - Loss of ambulation (inability to ambulate 10 meters) was used for transition from late ambulatory to early non-ambulatory
  - Loss of unweighted hand-to-mouth function (Brooke score ≥5) was used for transition from early to late non-ambulatory
- Mortality was based on pooled KM estimates from Broomfield et al.,[10] Passamano et al.,[11] and Paramsothy et al.[12] and extrapolated using a log-normal distribution
- Impact of using upper and lower CI values for all survival extrapolations was examined in sensitivity analyses

Figure 4. Proportion of Patients in Each Health State by Age



DMD=Duchenne muscular dystrophy; EA=early ambulatory; ENA=early non-ambulatory; LA=late ambulatory; LNA=late non-ambulatory.

Estimating general population work productivity by age

- Median annual salaries and employment rates by age group were obtained from the US Bureau of Labor Statistics (BLS) and were fitted with polynomial models to calculate the salary and employment rates for each age[13,14]
- Employment was assumed to start at a minimum age of 16 years, as reported by the BLS
- Annual salary growth and discounting begin at the start of the analysis, when the patient with DMD is 5 years old (based on median age of diagnosis)[15]; annual salary growth is still applied when the results are undiscounted
- For caregivers, annual salary growth and discounting in the model begin when the caregivers are 32 years old (based on an average age of 27 years old for having a first child)[16]

Estimating loss of work productivity due to DMD

- Loss of work productivity for patients with DMD and caregivers was estimated using the human capital approach, calculated as the potential earnings lost due to loss of work opportunity as a result of illness[17,18]
  - Male-specific employment, salary, and mortality data were used to estimate loss of work productivity for patients with DMD
- Alternative scenarios for workforce participation for patients in late ambulatory and early non-ambulatory health states were explored
- LOI for patients with DMD was calculated as the difference between the employment and mortality-adjusted annual income of the US male population and patients with DMD
- Work years lost was calculated as the difference between the employment and mortality-adjusted employment rates in the US male population and patients with DMD

Caregivers

- Loss of work productivity for caregivers was estimated from a US study examining labor productivity costs of female caregivers of patients with DMD[8]
  - Mean annualized working hours lost was estimated based on regression models, accounting for reduced participation in the labor force and changes in working patterns
- LOI for caregivers was estimated using median salaries, employment rates, and all-cause mortality
- Sensitivity of the results to using female-only employment inputs and the annual hours worked per year were investigated

ADDITIONAL RESULTS

Figure 5a. US Male Population vs Patients With DMD Mortality- and Employment-adjusted Annual Salaries

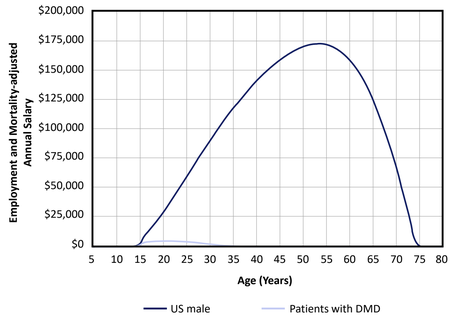


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Figure 5b. Cumulative Lifetime Loss of Income in Patients With DMD

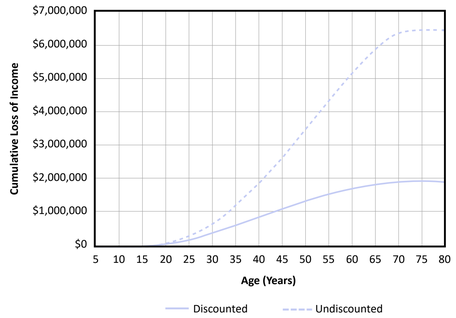

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Figure 6a. Annual Salaries for the US Population and Modeled for Caregivers of Patients With DMD, Mortality- and Employment-adjusted

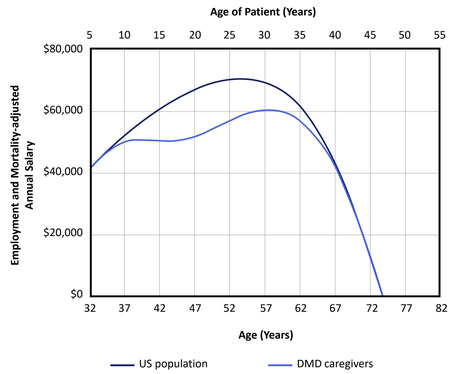

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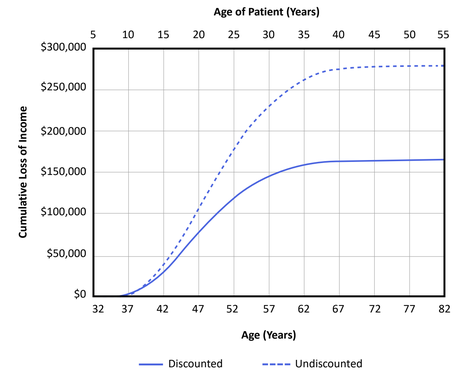
Figure 6b. Cumulative Lifetime Loss of Income for DMD Caregivers



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