MILLIMAN RESEARCH REPORT

2017 U.S. organ and tissue transplant cost estimates and discussion

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I. Overview

This 2017 report represents Milliman's triennial summary of estimated U.S. average costs per member per month (PMPM), billed charges, and utilization related to the 30 days prior and 180 days after transplant admission for treatment for organ and tissue transplants. For charges pre- and post-transplant admission, we include all medical costs associated with the transplant patient.

Organ transplants include single-organ transplants such as heart, intestine, kidney, liver, lung, pancreas, and a number of multiple-organ transplants.

Tissue transplants include bone marrow and cornea transplants. We split the bone marrow estimates by donor method: autologous, where the donor is the recipient, and allogeneic, where the donor may be related or unrelated to the recipient.

Highlights of this report include:

- **Section II**: The 2017 PMPM costs based on billed charges are estimated to be $8.21 and $12.23 for the under-age-65 and ages-65-and-over populations, respectively. These PMPM costs reflect average annual increases of 3.5% and 7.7% from our 2014 report.

  The trend for the under-age-65 population consists of a 0.5% composite utilization trend and a 3.0% composite billed charge trend. However, there is a wide range of annual utilization and charge trends by type of transplant for the under-age-65 population, with utilization trends from -11.2% to 17.2% and charge trends from -9.5% to 11.2%.

  The higher trend for the ages-65-and-over population is mainly due to the difference in the mix of transplants between the under-age-65 and ages-65-and-over populations.

  While billed charges increased about 3.0% per year, many recipients or health plans do not pay billed charges because of negotiated discounts from transplant provider networks.

  Hospital length of stay has been fairly stable for most transplants since our 2014 report. Our databases show a length of stay increase for heart transplants and decrease for intestine transplants.

- **Section IV:** Waiting times for kidney transplants and intestine transplants have decreased dramatically since our 2014 report. However, waiting times for organs such as heart and pancreas have increased since our 2014 report.

  Survival rates generally increased slightly from those in our 2014 report, except for pancreas.

II. Costs PMPM, charges, and utilization

Table 1 summarizes the estimated U.S. average 2017 transplant costs PMPM for the under-age-65 and ages-65-and-over populations. "Costs" means the product of utilization and billed charges. Table 2 summarizes the estimated U.S. average 2017 billed charges per transplant.

The estimated number of transplants shown in Table 1 reflects removal of transplants provided to foreign citizens. To determine utilization rates, we assumed 2017 U.S. under-age-65 and ages-65-and-over population estimates of 275.5 million and 51.1 million, respectively. These population estimates are based on the United States Census Bureau's resident population census estimates as of July 1, 2010, and projected to 2017.

Charges for pre-transplant, follow-up, outpatient (OP) immunosuppressants and other drugs used in our 2014 and 2017 reports cover the time period from 30 days pre-transplant to 180 days post-transplant discharge for follow-up and outpatient immunosuppressant and other drugs. Also for these categories, we included all medical costs associated with the transplant patient, not just those related to the transplant.

TABLE 1: ESTIMATED U.S. AVERAGE 2017 TRANSPLANT COSTS PER MEMBER PER MONTH (PMPM)

			Under Age 65			Ages 65 and Over		
Transplant	Total Estimated Number of Transplants	Estimated Billed Charges	Estimated Number of Transplants	Estimated Annual Utilization Per 1,000,000	Estimated Costs PMPM	Estimated Number of Transplants	Estimated Annual Utilization Per 1,000,000	Estimated Costs PMPM
Single Organ/Tissue								
Bone Marrow - Allogenic	9,284	$892,700	7,659	27.80	$2.07	1,625	31.80	$2.37
Bone Marrow - Autologous	12,160	409,600	8,877	32.23	1.10	3,283	64.24	2.19
Cornea	50,099	30,200	17,785	64.57	0.16	32,314	632.31	1.59
Heart	2,725	1,382,400	2,248	8.16	0.94	477	9.33	1.07
Intestine	49	1,147,300	48	0.17	0.02	1	0.02	0.00
Kidney	16,804	414,800	13,527	49.11	1.70	3,277	64.12	2.22
Liver	6,158	812,500	5,142	18.67	1.26	1,016	19.88	1.35
Lung - Single	673	861,700	323	1.17	0.08	350	6.85	0.49
Lung - Double	1,397	1,190,700	1,097	3.98	0.39	300	5.87	0.58
Pancreas	136	347,000	135	0.49	0.01	1	0.02	0.00
Multiple Organ								
Heart-Lung	21	2,564,000	20	0.07	0.01	1	0.02	0.00
Intestine with Other Organs	80	1,585,100	79	0.29	0.04	1	0.02	0.00
Kidney-Heart	130	2,530,900	107	0.39	0.08	23	0.45	0.09
Kidney-Pancreas	724	618,100	723	2.62	0.13	1	0.02	0.00
Liver-Kidney	682	1,229,700	549	1.99	0.20	133	2.60	0.27
Other Multi-Organ	35	1,855,400	33	0.12	0.02	2	0.04	0.01
TOTAL					**$8.21**			**$12.23**

DIFFERENCES FROM MILLIMAN'S 2017 HEALTH COST GUIDELINES

Users of both this report and the 2017 Milliman Health Cost Guidelines™ may notice differences in the estimated under-age-65 PMPM costs between the two sources. This report estimates total PMPM costs for under-age-65 recipients that are $0.13 lower than the 2017 Health Cost Guidelines as a result of using a different population in the Guidelines. Most of this decrease is attributed to autologous bone marrow and cornea.

CHARGES

Table 2 shows estimated U.S. average 2017 billed charges per transplant. Categories making up the total charges are defined below.

- **30 days pre-transplant:** These charges include all medical costs for the transplant patient incurred during the 30 days prior to the transplant hospital admission, which can include medical costs not related to the transplant. These charges could include history of the candidate, noting indications and contraindications for the transplant; comprehensive physical, psychological, and laboratory evaluations, including blood and tissue typing and serum and cell compatibility matching; cross-matching for donor compatibility; hepatitis and HIV screening; antibody screening; medical and psychological testing; lab tests; and X-rays. Because of the time period between evaluation and transplant, evaluation costs are exceedingly difficult to identify in claim databases, which are our primary source of charge data. Therefore, it is not practical to separate these charges into those related and not related to the transplant because of the short 30-day time period defined.
- **Procurement:** This includes donated organ or tissue recovery services, which may include retrieval, preservation, transportation, and other acquisition costs.
- **Hospital transplant admission:** This covers facility charges for the transplant only. Any re-admissions within 180 days of the transplant discharge date are included in the 180 Days Post-Transplant Discharge category, whether related to the transplant or not. Hospital services include room and board and ancillary services such as use of surgical and intensive care facilities, inpatient nursing care, pathology and radiology procedures, drugs, supplies, and other facility-based services. Hospital services may also include use of immunosuppressive and other drugs provided during the hospital stay.
- **Physician during transplant admission:** These are charges for professional services while the recipient is hospitalized for the transplant, including surgery procedures and other services identified by CPT or HCPCS procedure codes.
- **180 days post-transplant discharge:** This covers post-discharge facility and professional services, including any hospital readmissions. Services may also include regular lab tests, regular outpatient visits, and evaluation and treatment of complications. These services can include both those related and not related to the transplant.
- **OP immunosuppressants and other Rx:** This category includes all outpatient drugs prescribed from discharge for the transplant admission to 180 days post-transplant discharge, including immunosuppressants, other drugs related to the transplant, and other drugs not related to the transplant. Anti-anxiety medications, antifungal antibiotics, anti-virals, colony-stimulating factors, gastrointestinal drugs, hypertension drugs, and post-operative pain management drugs are examples of drugs other than outpatient immunosuppressants related to the transplant that could also be used in treatment. Immunosuppressant drug charges in this report include assumed discounts of 60% and 15% from average wholesale prices for generics and brand drugs, respectively, which is similar to the Health Cost Guidelines assumptions for all prescription drugs.

TABLE 2: ESTIMATED U.S. AVERAGE 2017 BILLED CHARGES PER TRANSPLANT

Transplant	30 Days Pre-Transplant	Procurement	Hospital Transplant Admission	Physician During Transplant Admission	180 Days Post-Transplant Discharge	OP Immuno-Suppressants & Other Rx	Total
Single Organ/Tissue							
Bone Marrow - Allogenic	$60,200	$72,200	$465,200	$22,600	$249,800	$22,700	$892,700
Bone Marrow - Autologous	61,500	15,300	226,300	10,700	81,300	14,500	409,600
Cornea	NA	NA	21,900	8,300	NA	NA	30,200
Heart	43,300	102,100	887,400	92,300	222,800	34,500	1,382,400
Intestine	28,400	106,100	669,600	60,000	260,600	22,600	1,147,300
Kidney	30,100	96,800	159,400	24,900	75,000	28,600	414,800
Liver	41,400	94,100	463,200	56,100	126,900	30,800	812,500
Lung - Single	27,900	106,100	475,000	49,600	163,200	39,900	861,700
Lung - Double	38,800	127,600	679,100	68,900	226,500	49,800	1,190,700
Pancreas	13,400	97,900	131,400	19,600	62,600	22,100	347,000
Multiple Organ							
Heart-Lung	93,100	155,900	1,731,900	162,800	373,600	46,700	2,564,000
Intestine with Other Organs	69,000	260,700	803,200	96,600	313,000	42,600	1,585,100
Kidney-Heart	136,300	126,700	1,582,100	163,900	450,200	71,700	2,530,900
Kidney-Pancreas	36,500	135,100	274,500	35,900	107,000	29,100	618,100
Liver-Kidney	77,000	160,100	648,900	81,700	216,900	45,100	1,229,700
Other Multi-Organ	85,500	188,400	1,078,900	122,700	327,500	52,400	1,855,400

BASIS OF UTILIZATION AND CHARGE ESTIMATES

We based utilization estimates on data from the U.S. Organ Procurement and Transplantation Network (OPTN), the U.S. Health Resources and Services Administration (HRSA), and the Eye Bank Association of America. None of the entities on which we relied for data have reviewed or approved our estimates. The content of this report is the responsibility of the authors alone and does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. government.

We developed charge estimates for 30 days pre-transplant, physician during transplant, 180 days post-transplant discharge, and non-immunosuppressant drugs based on Milliman proprietary claim data. We based procurement charge estimates on 2014 Arizona, Iowa, Maryland, Massachusetts, Texas, Vermont, and Washington state hospital data, trended to 2017, and normalized to a national average basis using Milliman area relativity research.

We based hospital charge estimates on 2014 Arizona, Florida, Iowa, Maryland, Massachusetts, Texas, Utah, Vermont, Virginia, Washington state, and Wisconsin hospital data, trended to 2017, and normalized to a national average basis using Milliman area relativity research.

Our bone marrow charge estimates do not reflect any charges from outpatient treatment because we lacked sufficient outpatient bone marrow data.

We developed cornea hospital charges from 2014 Wisconsin hospital inpatient and outpatient data. The 2014 Wisconsin hospital data showed that outpatient cornea transplants represent more than 99% of these transplants and more than 99% of billed charges.

We assumed no outpatient immunosuppressant charges for autologous bone marrow and cornea transplants. For all other transplants, outpatient immunosuppressant charges begin after our estimated date of discharge, which is based on 2014 hospital lengths of stay and trended to 2017. Average wholesale prices were based on the Medi-Span database, the MarketScan commercial database, and our judgment to project these charges to 2017. Average dosing regimens were based on Clinical Pharmacology and our judgment. Average immunosuppressant use by drug was based on the Scientific Registry of Transplant Recipients 2014 Annual Data Report.

HOSPITAL LENGTHS OF STAY

Table 3 shows that estimated hospital lengths of stay have been fairly stable for most transplants since our 2014 report.

TABLE 3: HOSPITAL LENGTHS OF STAY BY TRANSPLANT (DAYS)

Transplant	2014 Report 2011 State Databases	2017 Report 2014 State Databases
Single Organ/Tissue		
Bone Marrow - Allogenic	33.3	33.8
Bone Marrow - Autologous	19.7	19.8
Heart	40.2	48.6
Intestine	78.8	42.5
Kidney	6.9	6.8
Liver	21.0	20.4
Lung - Single	21.2	22.4
Lung - Double	29.5	28.3
Pancreas	8.8	10.5
Multiple Organ		
Heart-Lung	41.7	63.6
Intestine with Other Organs	NA	75.6
Kidney-Heart	53.5	81.6
Kidney-Pancreas	10.9	10.8
Liver-Kidney	32.7	32.9
Other Multi-Organ	NA	46.7

ANNUAL NUMBER OF TRANSPLANTS

Tables 4A, 4B, and 4C show the annual number of transplants performed in the United States from 2013 to 2017. These numbers include all ages and transplants for U.S. citizens. We project increases in the numbers of some transplants from 2016 to 2017 because of projected population increases, even though the expected transplant rate per million people may decrease for various types of transplants.

We based Tables 4A and 4B on OPTN data as of December 31, 2016. We estimated the split of lung transplants between single and double lung using 2014 state hospital databases and our judgment. We based the bone marrow estimates in Table 4C on HRSA data. We based the cornea estimates in Table 4C on information from the 2015 Eye Banking Statistical Report.

TABLE 4A: SINGLE-ORGAN TRANSPLANTS PERFORMED IN THE UNITED STATES

Year	Heart	Intestine	Kidney	Liver	Lung-Single	Lung-Double	Pancreas
2013	2,408	36	16,139	5,803	602	1,293	189
2014	2,512	48	16,236	5,972	596	1,287	161
2015	2,603	48	16,845	6,264	700	1,321	144
2016*	2,664	49	16,825	6,211	687	1,359	140
2017*	2,725	49	16,804	6,158	673	1,397	136

* Milliman estimates

TABLE 4B: MULTIPLE-ORGAN TRANSPLANTS PERFORMED IN THE UNITED STATES

Year	Heart-Lung	Intestine with Other Organs	Kidney-Heart	Kidney-Pancreas	Liver-Kidney	Other Mutli-Organ
2013	23	64	85	760	494	31
2014	23	82	104	709	558	31
2015	15	82	141	715	626	41
2016*	18	81	136	720	654	38
2017*	21	80	130	724	682	35

* Milliman estimates

TABLE 4C: TISSUE TRANSPLANTS PERFORMED IN THE UNITED STATES

Year	Bone Marrow - Autologous	Bone Marrow - Allogenic	Cornea
2013	10,978	8,338	48,229
2014	11,392	8,470	47,530
2015	12,626	8,774	48,792
2016*	12,393	9,029	49,446
2017*	12,160	9,284	50,099

* Milliman estimates

REGIONAL DISTRIBUTION OF TRANSPLANTS

Table 5 shows the distribution of transplants performed in the United States in 2016 based on the OPTN regional structure. The table is based on OPTN data as of December 31, 2016, and the United States Census Bureau's resident population census estimates as of July 1, 2010, and projected to 2016.

Region 2 (Delaware, District of Columbia, Maryland, New Jersey, Pennsylvania, West Virginia) and Region 7 (Illinois, Minnesota, North Dakota, South Dakota, Wisconsin) have the highest transplants per capita in the United States. Region 6 (Alaska, Hawaii, Idaho, Montana, Oregon, Washington state) has the lowest transplants per capita in the United States.

TABLE 5: 2016 UTILIZATION (PER 1,000,000) OF TRANSPLANTS BY OPTN REGION

Transplant	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10	Region 11
Single Organ/ Tissue											
Heart	9.9	9.5	7.6	10.7	8.9	6.9	9.9	10.0	8.6	9.2	11.1
Intestine	0.1	0.5	0.2	0.0	0.1	0.0	0.0	0.3	0.3	0.8	0.0
Kidney	57.0	71.2	45.4	57.5	57.3	39.0	63.6	54.3	68.6	51.6	49.8
Liver	23.0	28.6	24.0	21.7	19.1	13.0	21.8	21.3	17.9	21.9	19.8
Lung (Single and Double)	6.7	11.5	4.5	9.4	7.3	3.2	6.8	6.9	3.2	9.9	6.6
Pancreas	0.4	0.4	0.3	0.3	0.3	0.1	1.7	0.2	0.6	0.5	0.2
Multiple Organ											
Heart-Lung	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Intestine with Other Organs	0.1	0.4	0.3	0.0	0.1	0.1	0.1	0.8	0.4	0.6	0.1
Kidney-Heart	0.1	0.4	0.4	0.5	0.6	0.2	0.5	0.2	0.5	0.4	0.5
Kidney-Pancreas	0.9	2.5	2.8	2.1	2.1	1.7	4.9	1.9	1.8	2.9	2.1
Liver-Kidney	1.5	3.0	2.5	2.8	2.2	0.6	3.0	1.3	1.7	2.7	1.8
Other Multi-Organ	0.1	0.1	0.1	0.2	0.2	0.0	0.1	0.0	0.1	0.2	0.0

Region 1: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Eastern Vermont
Region 2: Delaware, District of Columbia, Maryland, New Jersey, Pennsylvania, West Virginia
Region 3: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Puerto Rico
Region 4: Oklahoma, Texas
Region 5: Arizona, California, Nevada, New Mexico, Utah
Region 6: Alaska, Hawaii, Idaho, Montana, Oregon, Washington state
Region 7: Illinois, Minnesota, North Dakota, South Dakota, Wisconsin
Region 8: Colorado, Iowa, Kansas, Missouri, Nebraska, Wyoming
Region 9: New York, Western Vermont
Region 10: Indiana, Michigan, Ohio
Region 11: Kentucky, North Carolina, South Carolina, Tennessee, Virginia

BONE MARROW CLASSIFICATIONS

Table 6 shows that bone marrow transplants can be classified according to graft source: bone marrow, peripheral blood stem cell, or umbilical cord blood stem cell. Generally speaking, allogeneic bone marrow cell graft use continues to increase and autologous peripheral blood stem cell graft use continues to increase.

TABLE 6: BONE MARROW TRANSPLANT GRAFT SOURCES, 2009-2013

	Graft Sources		
Age at Time of Transplant	Bone Marrow	Peripheral Blood Stem Cell	Cord Blood Stem Cell
Autologous			
Under 21	About 2%	About 98%	About 0%
21+	About 0%	About 100%	About 0%
Allogenic			
Under 21	About 53%	About 21%	About 26%
21+	About 13%	About 80%	About 7%

Source: Table 20. 2015 CIBMTR Transplant Activity Report Covering 2009-2013

ACTUAL COSTS VERSUS MILLIMAN ESTIMATES

As we mentioned in Section II, "costs" means the product of utilization and billed charges. We did not research the actual reimbursement that hospitals and physicians receive to provide transplants, as that would involve proprietary contractual arrangements. Actual PMPM transplant costs may vary from our estimates for a variety of reasons that are beyond the scope of our report:

- The transplant cost estimates assume full insurance coverage; patient cost-sharing and benefit limitations would reduce full coverage costs.
- Costs may vary by geographic area and transplant center due to volume or incidence of complications.
- Changes in the average number of organs procured per donor and number of centers may change costs, as long as suitable donor organs and tissue can continue to be found.
- Private insurance, Medicare, Medicaid, and uninsured recipient costs may vary by transplant; for example, Medicare covers a significant portion of kidney transplants through the End Stage Renal Disease program.
- Federal and state legislative efforts and private initiatives may change utilization and costs.
- Changes in selection criteria may affect costs.
- Costs may vary by underlying diagnosis and/or disease state.
- Medical management may reduce costs, particularly with respect to hospital charges.
- Costs may be reduced with use of cost-control mechanisms such as greater donor and recipient selectivity by centers, critical pathways to reduce inpatient lengths of stay, and aggressive use of outpatient therapies and other more cost-effective treatments.
- Wide availability of mechanical, artificial, or cloned organs, experimental procedures becoming accepted practice, or other innovations may affect costs.
- Cost estimates may be subject to change if the OPTN data and other data relied on changes due to future data submissions or corrections.
- Administration costs and profit margins will vary and were not considered in our analysis.
- Any estimate of costs after the first year should reflect adjustments for trend, survival, and probability of re-transplantation.

ACTUAL CHARGES COMPARED TO MILLIMAN BILLED CHARGE ESTIMATES

"Charges" in this report refer to the amount billed, which may not be the actual amount paid for the transplant services due to the presence of case rates, discounts, or other negotiated reimbursement arrangements. Significant reductions from billed charge levels may be obtained and the chances for successful treatment may be maximized by directing patients to specific centers. Actual charges will likely vary for private insurers, Medicare, or Medicaid.

Negotiated case rates may combine hospital and physician charges. Procurement charges may be included in the negotiated case rate, but usually the procurement charges reflect slight, if any, discounts from billed levels.

We have observed that case rates do not typically cover pre-transplant medical services and maintenance therapy outpatient immunosuppressants. Some case rates may include follow up costs within a specified time period such as the first 90 days after discharge. Services and charges not defined under a case rate may be provided by the patient's normal provider network.

Some transplant centers address charge variation by developing separate payment rates by diagnosis or by patient disease state. Our charge estimates are not adjusted to reflect diagnosis, disease state, or other variables specific to a given situation.

An outlier provision may provide additional payment beyond the case rate after a specified number of days in the hospital or after a certain level of billed charges. The outlier provision may pay for hospital days at a discount from billed charges or at a per diem rate. Centers may also have outlier payments for physician services.

Actual outpatient immunosuppressant charges will vary from our estimates for several reasons:

- Actual hospital lengths of stay will vary from our estimates, which affects the amount of time that outpatient immunosuppressants are required.
- Drug discounts other than those assumed in this report will yield different estimates.
- Actual dosing regimens will vary from the dosing regimens assumed.
- The actual use and prevalence of single and multiple outpatient immunosuppressant regimens will vary from our estimates.

The transplant charge estimates do not reflect differences in charges due to age. Billed transplant charges may vary for pediatric patients, adults under the age of 65, and patients ages 65 and over.

Charges may continue after the first year and may include continued testing and evaluation, medical services for transplant rejection, and outpatient immunosuppressants.

III. Primary diagnoses

Table 7 summarizes the most common primary indications for transplantation by organ/tissue. Organ data is based on data from the 2014 OPTN/SRTR Annual Report. Bone marrow data is based on 2013 North American data from the CIBMTR 2015 Summary Slides. Cornea data is based on the 2015 Eye Banking Statistical Reports. Since our 2014 report, the order and magnitude of the top indications have changed slightly for several types of transplants.

TABLE 7: INDICATIONS FOR TRANSPLANT

Organ or Tissue	Most Common Primary Diagnosis and Prevalence	Second-Most-Common Primary Diagnosis and Prevalence	Third-Most-Common Primary Diagnosis and Prevalence
Single Organ/Tissue			
Bone Marrow - Allogenic	Acute Myelogenous Leukemia (37%)	Myelodysplastic Syndrome/ Myeloproliferative Disease (16%)	Acute Lymphocytic Leukemia (14%)
Bone Marrow - Autologous	Multiple Myeloma (57%)	Non-Hodgkin's Lymphoma (27%)	Hodgkin's Disease (8%)
Cornea	Fuchs' Dystrophy (22%)	Post-Cataract Surgery Edema (11%)	Repeat Corneal Transplant (10%)
Heart	Cardiomyopathy (52%)	Coronary Artery Disease (32%)	Congenital Disease (10%)
Intestine	Short Gut Syndrome: Other (58%)	Short Gut Syndrome: Congenital (14%)	Short Gut Syndrome: Necrotizing Enterocolitis (5%)
Kidney	Diabetes (27%)	Hypertension (20%)	Glomerulonephritis (19%)
Liver	Hepatitis C Virus (23%)	Malignancy (20%)	Alcoholic Liver Disease (17%)
Lung (Single and Double)	Restrictive Lung Disease - Idiopathic Pulmonary Fibrosis (56%)	Obstructive Lung Disease - COPD/Emphysema (27%)	Cystic Fibrosis (13%)
Pancreas	Diabetes Mellitus - Type I (70%)	Diabetes Mellitus - Type II (2%)	Diabetes Mellitus - Type Unknown (1%)
Multiple Organ			
Kidney-Pancreas	Diabetes Mellitus - Type I (86%)	Diabetes Mellitus - Type II (9%)	Diabetes Mellitus - Type Unknown (1%)

IV. Waiting times and survival rates

WAITING TIMES

Table 8 summarizes transplant waiting times in days by organ, based on data from the 2011 and 2014 OPTN/SRTR Annual Reports. The waiting times reflect a patient who has been registered on a waiting list and takes into account all the events that can happen to the patient after wait listing, such as receiving a transplant, being removed from the waiting list, and dying. No data is shown for bone marrow because we were unable to find a data source for tissue transplant waiting times.

The waiting times shown in Table 8 are estimates of averages. For example, a candidate for a heart transplant has an average waiting time of 191 days.

Table 8 also shows that waiting times vary by organ over time. Waiting times may also vary by other characteristics not shown.

TABLE 8: WAITING TIMES BY TRANSPLANT

Organ	2011	2014
	Average Waiting Time in Days	
Heart	180	191
Intestine	207	181
Kidney	877	679
Liver	232	239
Lung (Single and Double)	181	185
Pancreas Alone	236	281
Pancreas after Kidney	472	532
Kidney-Pancreas	414	394

SURVIVAL RATES

Table 9 summarizes one-year, three-year, and five-year patient survival rates by transplant. The organ transplant survival rates for patients transplanted during 2008 through 2015 generally show improvement from those in our 2014 report and are based on the OPTN/SRTR data as of December 31, 2016.

Bone marrow transplant survival rates are based on 2003 to 2013 CIBMTR survival rate data. Autologous and allogeneic survival rates vary significantly by individual diagnosis, age, type of donor, and disease stage. We developed composite autologous bone marrow estimates reflecting survival rates for multiple myeloma, non-Hodgkin's lymphoma, Hodgkin's disease, and acute myelogenous leukemia, which represented more than 93% of all North American autologous bone marrow transplants in 2013. The composite allogeneic bone marrow estimates we developed reflect survival rates for acute myelogenous leukemia, acute lymphoblastic leukemia, myelodysplasia, non-Hodgkin's lymphoma, aplastic anemia, chronic myelogenous leukemia, multiple myeloma, and Hodgkin's disease, which represent more than 89% of all allogeneic bone marrow transplants in 2013. The CIBMTR has not reviewed or approved our composite survival estimates.

TABLE 9: PATIENT SURVIVAL RATES BY TYPE AND YEAR OF TRANSPLANT

	One-Year		Three-Year		Five-Year	
Organ	**2017 Report**	**2014 Report***	**2017 Report**	**2014 Report***	**2017 Report**	**2014 Report***
Heart	91%	89%	85%	82%	78%	75%
Intestine	81	80	67	63	58	53
Kidney	97	96	93	92	86	86
Liver	91	89	83	81	75	74
Lung (Single and Double)	87	85	69	66	55	51
Pancreas	92	93	88	89	80	81
Heart-Lung	80	73	59	54	51	45
Kidney-Pancreas	98	96	95	92	88	87
Tissue	**2003-2013**	**2000-2010**	**2003-2013**	**2000-2010**	**2003-2013**	**2000-2010**
Bone Marrow - Autologous	90-94%	85-89%	72-76%	67-71%	61-65%	54-58%
Bone Marrow - Allogenic	65-69%	61-65%	48-52%	48-52%	46-50%	43-47%

*2014 report values have been updated to reflect changes in our development methods of survival rates.

V. 2016 recipient demographics

Tables 10A and 10B highlight 2016 transplant recipient demographics. The demographic data and categories are based on OPTN/SRTR data as of December 31, 2016, for solid organs and 2014 state hospital databases for bone marrow.

TABLE 10A: 2016 RECIPIENT DEMOGRAPHICS: SINGLE-ORGAN/TISSUE TRANSPLANTS

	Bone Marrow	Heart	Intestine	Kidney	Liver	Lung	Pancreas
Gender							
Male	60%	71%	59%	60%	65%	58%	49%
Female	40	29	41	40	35	42	51
Total	100%	100%	100%	100%	100%	100%	100%
Race							
White	69%	62%	66%	46%	70%	81%	82%
Black	11	22	15	27	9	9	4
Hispanic	14	11	15	19	15	7	10
Asian	3	3	4	6	4	2	3
Other	3	2	0	2	2	1	1
Total	100%	100%	100%	100%	100%	100%	100%
Age (At Time of Transplant)							
Under 1	1%	4%	0%	0%	2%	0%	0%
1-5	4	3	16	1	3	0	0
6-10	3	2	12	1	1	0	0
11-17	4	5	3	2	1	1	0
18-34	11	9	22	13	6	11	22
35-49	14	17	24	27	16	11	45
50-64	40	43	23	38	52	47	32
65+	23	17	0	18	19	30	1
Total	100%	100%	100%	100%	100%	100%	100%

TABLE 10B: 2016 RECIPIENT DEMOGRAPHICS: MULTIPLE-ORGAN TRANSPLANTS

	Heart-Lung	Intestine with Other Organs	Kidney-Heart	Kidney-Pancreas	Liver-Kidney	Other Multi-Organ
Gender						
Male	44%	62%	80%	60%	62%	62%
Female	56	38	20	40	38	38
Total	100%	100%	100%	100%	100%	100%
Race						
White	72%	65%	45%	56%	62%	75%
Black	6	18	37	26	16	10
Hispanic	6	15	11	14	16	9
Asian	16	1	5	2	4	6
Other	0	1	2	2	2	0
Total	100%	100%	100%	100%	100%	100%
Age (At Time of Transplant)						
Under 1	0%	6%	0%	0%	0%	0%
1-5	0	29	0	0	1	3
6-10	0	8	1	0	0	3
11-17	6	4	1	0	1	3
18-34	33	16	9	24	6	22
35-49	22	18	20	54	16	19
50-64	39	19	50	22	56	44
65+	0	0	19	0	20	6
Total	100%	100%	100%	100%	100%	100%

VI. Donor facts and data

DECEASED DONOR

Deceased donor data reflects only donors recovered by U.S. organ procurement organizations. United Network for Organ Sharing defines a recovered, deceased donor as one from whom at least one vascularized solid organ—heart, intestine, kidney, liver, lung, or pancreas—was recovered for transplantation. Hearts recovered for heart valves are not counted.

Table 11 summarizes U.S. deceased donor counts from 2013 to 2016, based on OPTN data as of December 31, 2016. Unlike Tables 1, 4A, and 4B, heart, intestine, kidney, liver, lung, and pancreas transplants in Table 11 include multiple-organ transplants with that organ. Heart-lung and kidney-pancreas transplants are the exception, as those transplants are counted separately and only counted once.

TABLE 11: PRIMARY ORGAN TRANSPLANTS FROM DECEASED DONORS

Year	Heart	Intestine	Kidney	Liver	Lung	Pancreas	Heart-Lung	Kidney-Pancreas
2013	2,531	108	11,163	6,203	1,922	256	23	761
2014	2,655	138	11,570	6,450	1,925	245	24	709
2015	2,804	139	12,250	6,768	2,057	228	15	719
2016	3,190	147	13,430	7,496	2,327	215	18	797

LIVING DONOR

The most common transplants using living donors include bone marrow, kidney, and liver. However, intestine, lung, pancreas, and kidney-pancreas transplants can also use living donors. Living lung donors have a segment of one lung removed for transplants. Lung lobes do not regenerate the donated segment, but an average decrease in the living donor's lung capacity generally yields minimal physical limitations for the donor. The liver can regenerate the donated segment. A donor may live with one kidney with little danger because the remaining kidney enlarges to do the work that both kidneys previously shared.

Living donor data includes living donors from whom organs were transplanted in the United States. The number of living donor transplants may differ from the number of living donors because living donors might donate segments from more than one organ, or there may be multiple donors for one transplant.

Table 12 summarizes U.S. living donor counts from 2013 to 2016, based on OPTN data as of December 31, 2016. Unlike Tables 1, 4A, and 4B, intestine, kidney, liver, lung, and pancreas transplants include multiple-organ transplants with that organ. Kidney-pancreas transplants are the exception, as these transplants are counted separately and only counted once.

TABLE 12: PRIMARY ORGAN TRANSPLANTS FROM LIVING DONORS

Year	Intestine	Kidney	Liver	Lung	Pancreas	Kidney-Pancreas
2013	1	5,733	252	1	0	1
2014	1	5,538	280	0	0	0
2015	2	5,628	359	0	0	0
2016	0	5,627	345	0	0	0

VII. Table index

Milliman is among the world's largest providers of actuarial and related products and services. The firm has consulting practices in life insurance and financial services, property & casualty insurance, healthcare, and employee benefits. Founded in 1947, Milliman is an independent firm with offices in major cities around the globe.

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