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Costs of malaria treatment in the United States

Joohyun Park, PhD¹, Heesoo Joo, PhD¹, Brian A. Maskery, PhD¹, Jonathan D. Alpern, MD^{2,3,4}, Michelle Weinberg, MD¹, William M. Stauffer, MD, MSPH^{1,3}

¹Division of Global Migration and Quarantine, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA,

²HealthPartners Institute, Minneapolis, MN, USA,

³Department of Medicine, University of Minnesota, Minneapolis, MN, USA

⁴Division of Infectious Diseases, Minneapolis Veterans Affairs Healthcare System, Minneapolis, MN, USA

Abstract

We estimated inpatient and outpatient payments for malaria treatment in the USA. The mean cost per hospitalized patient was significantly higher than for non-hospitalized patients (e.g. \$27 642 vs \$1177 among patients with private insurance). Patients with severe malaria paid two to four times more than those hospitalized with uncomplicated malaria.

Keywords

Malaria; treatment cost; inpatient; outpatient; United States

Approximately 2000 malaria cases are reported annually in the USA, with an increasing trend in recent decades.¹ Most US cases are diagnosed in travellers from malaria-endemic areas, and the US Centers for Disease Control and Prevention (CDC) recommends that travellers be provided prevention strategies, including chemoprophylaxis, prior to departure.² Some authors have identified cost barrier to accessing pre-travel malaria prevention care, especially among US-based travellers visiting friends and relatives.³ Although malaria can cause substantial morbidity, mortality and economic burden,^{4,5} few studies have reported costs associated with treatment of malaria in the USA. Using

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*To whom correspondence should be addressed. jpark3@cdc.gov.

Author Contributions

JP did the study design, literature search, data analysis and data interpretation and drafted the manuscript; HJ and BAM did the study design and data interpretation, supported the data analysis and reviewed the manuscript. MW contributed to developing the study concept and design and reviewed the manuscript. JDA and WMS contributed to the study design, supported the data interpretation and reviewed the manuscript. All authors contributed to the review, editing, final drafting and commenting on the manuscript.

Conflict of Interest/Disclosure

Dr Stauffer reported receiving partial chapter royalties from UpToDate and an honorarium from Haymarket Education outside the submitted work and acting as a consultant for BCTPartners. All remaining authors have declared no conflicts of interest.

Disclaimer

The findings and conclusions in this study are those of the authors and do not necessarily represent the official position of the US Centers for Disease Control and Prevention.

administrative claims databases, we estimated inpatient and outpatient payments for malaria treatment among patients with private insurance and Medicaid.

We identified patients with a first diagnosis of malaria from October 2015 to December 2019 in the Merative® MarketScan® Commercial and Multi-state Medicaid Databases, using the International Classification of Diseases, Tenth revision, Clinical Modification diagnosis codes of malaria (Supplementary Appendix 1). We excluded patients (1) with Medicare, (2) with capitated insurance plans or (3) who were not continuously enrolled between 30 days before and 90 days after the first diagnosis of malaria. We categorized patients as hospitalized or non-hospitalized; hospitalized patients were further categorized depending on whether malaria was the primary diagnosis. Among the hospitalized patients, we also identified those with severe malaria defined as having one or more of the following diagnoses or procedures: neurologic symptoms, severe anaemia with blood transfusion, renal failure, acute respiratory distress syndrome, jaundice, exchange transfusion and in-hospital death.⁴ The CDC definition of severe malaria also includes criteria based on laboratory test results or prescription drug use during hospitalization; however the MarketScan database does not fully capture this information and we had to omit this criteria from our definition. For each category, we investigated demographic and selected clinical characteristics and estimated mean inpatient and outpatient costs (including prescription drug costs) per person associated with the first malaria diagnosis between 1 October 2015 and 31 December 2019, using reported payments (i.e. reimbursement made by insurers and patients to providers for services). We included an observation period of up to 120 days to include additional treatment costs associated with the initial malaria diagnosis for each patient. Details of data sources, patient identification and cost estimation are described in Supplementary Appendices 1–3. All costs were adjusted to 2019 US dollars using the Consumer Price Index for medical care.⁶ Data were analysed using Stata SE 16.1.

We identified 479 malaria patients with private insurance and 64 malaria patients with Medicaid, of which 64 and 73% were hospitalized, respectively. For privately insured patients with malaria, the majority (62–67%) were male and around half were 40–64 years old and resided in the South region of the USA (Table 1 and Supplementary Appendix 4). The majority of hospitalized (80%) and non-hospitalized patients (55%) had a *Plasmodium falciparum* malaria diagnosis. Privately insured hospitalized patients with non-primary malaria diagnoses had a higher proportion of severe malaria and longer hospital stays than those with primary malaria diagnoses ($p<0.05$). For Medicaid enrollees, the majority were <40 years old and *P.falciparum* was the most commonly diagnosed species among hospitalized patients (70%).

The mean total cost per person was \$27 642 [median \$14 712, interquartile range (IQR) \$8928–\$25 378] for hospitalized malaria patients with private insurance and \$19 361 (median \$6778, IQR \$3932–\$16 706) for hospitalized patients with Medicaid (Figure 1a and Supplementary Appendices 5 and 6). Among the hospitalized patients with private insurance, the mean total cost per person was less for those with primary malaria diagnoses (\$17 092) compared with non-primary diagnoses (\$44 004); inpatient services accounted for most of the total cost (97–99%) (Supplementary Appendix 5). Additionally, the total costs per person for those with severe malaria were two to four times greater than for patients

with uncomplicated malaria. The mean cost per person for non-hospitalized privately insured patients was \$1177 (median \$311, IQR \$177–\$1410), including outpatient services (\$1088) and prescription drugs (\$89) (Figure 1b). The costs for Medicaid enrollees with malaria were significantly lower than for privately insured patients: \$5996 for hospitalized patients with primary diagnoses and \$551 for non-hospitalized patients. Insurance covered most payments, particularly for Medicaid enrollees.

This is the first study to examine total inpatient and outpatient costs per malaria patient in the USA. Most malaria patients were hospitalized, consistent with a previous national surveillance report,¹ and the costs for hospitalized patients were approximately 24 times higher than for patients treated as outpatient-only. The overall mean inpatient payments for privately insured patients are within the range of previously reported mean estimates of hospital costs and charges per US malaria hospitalization from 2000 to 2014 (\$9945 and \$28 771, 2019 USD).⁴ The negotiated payments for individuals with private insurance should fall between the reported hospital costs and charges. Hospital charges are list prices of services, which are the amount that hospitals may initially bill uninsured patients who lack the bargaining power of insurers (i.e. private insurers or public insurance programs such as Medicare or Medicaid).⁷ At the hospital level, costs (i.e. actual expense incurred in the production of services) can be estimated from charges using hospital-specific cost-to-charge ratios, which are calculated using the total hospital costs divided by the total hospital charges within a year.⁷

Consistent with the previous study, our study reported lower costs among inpatients with primary diagnoses (versus non-primary diagnoses).⁴ We suspect that the higher cost associated with non-primary diagnoses reflected patients with more severe malaria presenting with a more advanced stage of disease. As the primary diagnosis was determined based on the main reason for admission (i.e. principal diagnosis which is generally identified as the discharge diagnosis on a hospital claim) in the MarketScan Databases,⁸ it is likely that some patients with non-primary diagnoses arrived at hospitals with advanced or severe disease and had an alternate acute symptom based diagnosis prior to receiving the diagnosis of malaria (e.g. with sepsis or septic shock). These patients also tended to have more underlying health conditions or co-infections which may pre-dispose patients to more severe disease presentation. In addition, it is common for the diagnosis of malaria to be missed or delayed.^{9,10} This may explain why we observed a higher proportion of patients with severe malaria among hospitalized patients with non-primary diagnosis (versus primary diagnosis). Our study furthers the literature by providing cost estimates for non-hospitalized patients and including prescription drugs, treatment, or management costs before and after the initial hospitalization. The estimated costs of prescription drugs for non-hospitalized patients (mean \$89 and median \$46) in this study are in line with previous estimates based on pharmacy prices (median ranged from \$53 to \$222).¹¹

Limitations of our analysis include: (1) our sample populations are primarily comprised of those with either employer-sponsored private insurance or Medicaid (limited to 9–12 states) and may not be representative of the general US or Medicaid populations, (2) as we excluded individuals with Medicare or capitated plans due to their incomplete payment information, our estimates may be under or overestimated to the extent of the exclusion (3)

our inability to verify claims data and assess potential misdiagnoses of malaria, (4) possible incomplete capture of health care utilization such as rehabilitative care or over-the-counter medicines, (5) we used a modified definition of severe malaria due to limited laboratory test results or prescription drug data use during hospitalization and (6) we used reported payments to estimate costs, which depend on allowable reimbursement rates that may be lower for patients with Medicaid relative to negotiated payments for services provided to patients with private insurance.

Our findings provide the most recent estimates of the US-specific malaria treatment costs (2015–2019); however, our study period precedes the commercial entry of intravenous artesunate (approved in May 2020).^{12,13} This may further increase the cost of malaria treatment since artesunate is the only approved medication available for severe malaria treatment with an average price of more than \$30 000 for an average course of treatment.¹³ Future research may be undertaken to explore how the introduction of this drug will affect costs for hospitalized patients in the USA. Additionally, the cost estimates may provide important information for evaluating the cost-effectiveness of interventions, such as chemoprophylaxis, to reduce the risk of malaria infection among travellers or immigrants to the USA. Our study emphasizes the important role of pre-travel prevention strategies aimed at preventing malaria-associated morbidity in the USA, and our results may be used in cost-effectiveness analyses of specific interventions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

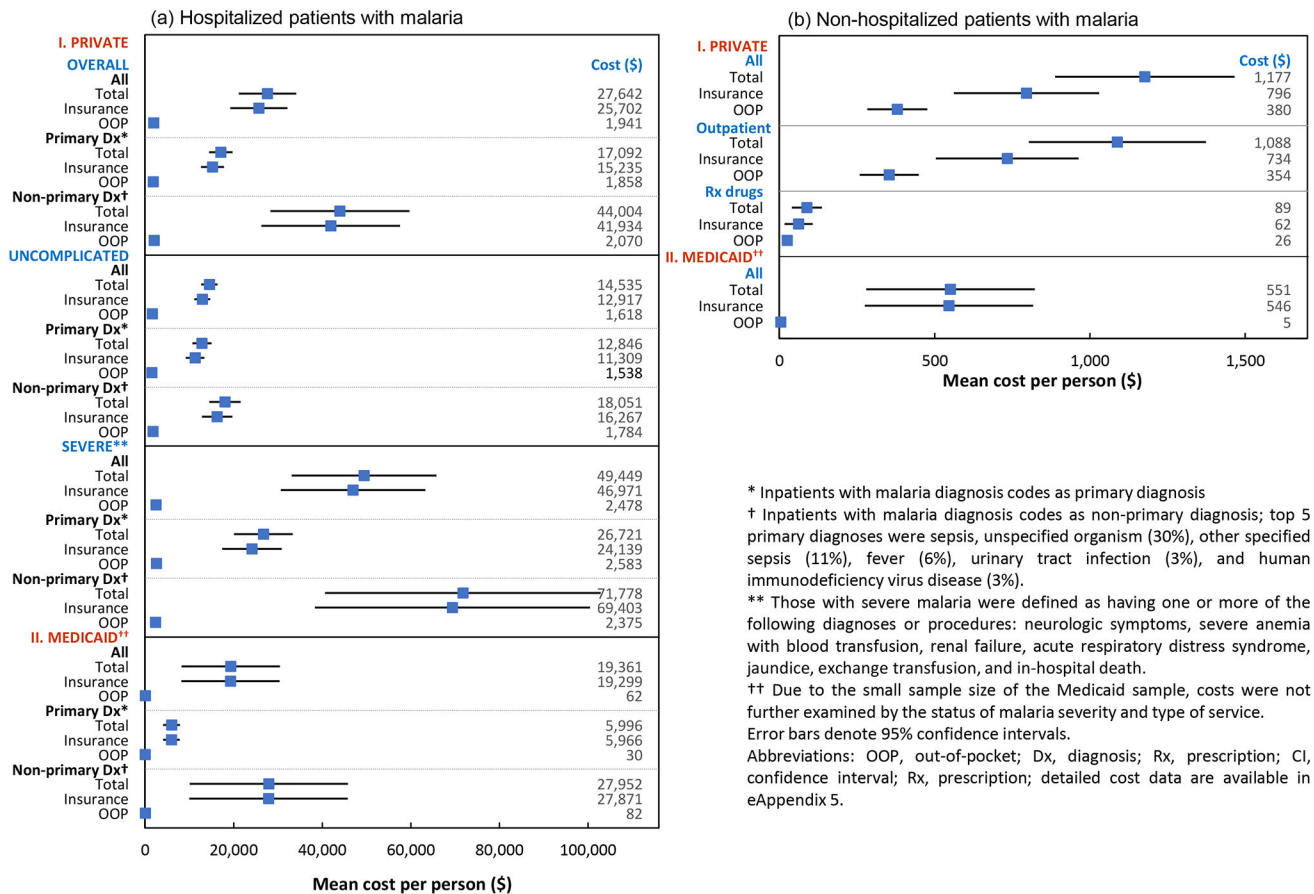
Data Availability Statement

The data that support the findings of this study are available from a third party, Merative, but restrictions apply to the availability of these data, which were used under licence for this study, and so are not publicly available.

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* Inpatients with malaria diagnosis codes as primary diagnosis
 † Inpatients with malaria diagnosis codes as non-primary diagnosis; top 5 primary diagnoses were sepsis, unspecified organism (30%), other specified sepsis (11%), fever (6%), urinary tract infection (3%), and human immunodeficiency virus disease (3%).
 ** Those with severe malaria were defined as having one or more of the following diagnoses or procedures: neurologic symptoms, severe anemia with blood transfusion, renal failure, acute respiratory distress syndrome, jaundice, exchange transfusion, and in-hospital death.
 †† Due to the small sample size of the Medicaid sample, costs were not further examined by the status of malaria severity and type of service.
 Error bars denote 95% confidence intervals.
 Abbreviations: OOP, out-of-pocket; Dx, diagnosis; Rx, prescription; CI, confidence interval; Rx, prescription; detailed cost data are available in eAppendix 5.

Figure 1. Estimated mean costs of malaria treatment per person among those with private insurance and those with Medicaid, October 2015–December 2019 Merative® MarketScan® Commercial Claims and Encounters Database and Multi-state Medicaid Database (2019 USD). * Inpatients with malaria diagnosis codes as primary diagnosis. † Inpatients with malaria diagnosis codes as non-primary diagnosis; top five primary diagnoses were sepsis, unspecified organism (30%), other specified sepsis (11%), fever (6%), urinary tract infection (3%) and human immunodeficiency virus disease (3%). ** Those with severe malaria were defined as having one or more of the following diagnoses or procedures: neurologic symptoms, severe anaemia with blood transfusion, renal failure, acute respiratory distress syndrome, jaundice, exchange transfusion and in-hospital death. †† Due to the small sample size of the Medicaid sample, costs were not further examined by the status of malaria severity and type of service. Error bars denote 95% confidence intervals. Abbreviations: OOP, out-of-pocket; Dx, diagnosis; Rx, prescription; CI, confidence interval; Rx, prescription; detailed cost data are available in Supplementary Appendix 5.

Table 1. Characteristics of study population, October 2015–December 2019 Merative® MarketScan® Commercial Claims and Encounters Database and Multi-state Medicaid Database

	Patients with Private Insurance				Patients with Medicaid				
	Hospitalized		Non-hospitalized		Hospitalized		Non-hospitalized		
	All	Primary Dx ^a	Non-primary Dx ^b	All	Primary Dx ^a	Non-primary Dx ^b	All	Primary Dx ^a	Non-primary Dx ^b
Sample size, No.	301	183	118	169	46	18	28	18	18
Age (years), Mean (SD)	38 (16.1)	37.1 (15.7)	39.9 (16.8)	39.0 (15.7)	32 (23.9)	29.6 (23.2)	33.6 (24.5)	22.5 (13.8)	22.5 (13.8)
Age (years), No. (%)									
0–17	37 (12.3)	23 (12.6)	14 (11.9)	15 (8.9)	15 (32.6)	9 (50.0)	6 (21.4)	7 (38.9)	7 (38.9)
18–39	106 (35.2)	69 (37.7)	37 (31.4)	63 (37.3)	14 (30.4)	2 (11.1)	12 (42.9)	9 (50.0)	9 (50.0)
40–64	158 (52.5)	91 (49.7)	67 (56.8)	91 (53.9)	12 (26.1)	6 (33.3)	6 (21.4)	2 (11.1)	2 (11.1)
65+	0	0	0	0	5 (10.9)	1 (5.6)	4 (14.3)	0	0
Sex, No. (%)									
Male	187 (62.1)	125 (68.3)	62 (52.5)	113 (66.9)	25 (54.3)	13 (72.2)	12 (42.9)	10 (55.6)	10 (55.6)
Female	114 (37.9)	58 (31.7)	56 (30.6)	56 (30.6)	21 (45.7)	5 (27.8)	16 (57.1)	8 (44.4)	8 (44.4)
Diagnosed <i>P. species</i> , No. (%) ^c									
<i>P. falciparum</i> ^d	174 (57.8)	124 (67.8)	50 (42.4)	27 (16.0)	26 (56.5)	11 (61.1)	15 (53.6)	3 (17.6)	3 (17.6)
<i>P. vivax</i> ^d	11 (3.7)	7 (3.8)	4 (3.4)	7 (4.1)	4 (8.7)	0	4 (14.3)	3 (17.6)	3 (17.6)
<i>P. ovale</i> ^d	6 (2.0)	5 (2.7)	1 (0.8)	1 (0.6)	0 (0.0)	0	0	0	0
<i>P. malariae</i> ^d	13 (4.3)	8 (4.4)	5 (4.2)	1 (0.6)	3 (6.5)	2 (11.1)	1 (3.6)	1 (5.9)	1 (5.9)
<i>P. knowlesi</i> ^d	2 (0.7)	1 (0.5)	1 (0.8)	2 (1.2)	0 (0.0)	0	0	0	0
Other malaria ^d	20 (6.6)	11 (6.0)	9 (7.6)	11 (6.5)	4 (8.7)	3 (16.7)	1 (3.6)	1 (5.9)	1 (5.9)
Unspecified malaria	96 (31.9)	39 (21.3)	57 (48.3)	121 (71.6)	12 (26.1)	3 (16.7)	9 (32.1)	10 (55.6)	10 (55.6)
Malaria severity, No. (%)									
Uncomplicated	188 (62.5)	127 (69.4)	61 (51.7)	N/A	29 (63.0)	13 (72.2)	16 (57.1)	N/A	N/A
Severe ^e	113 (37.5)	56 (30.6)	57 (48.3)	N/A	17 (37.0)	5 (27.8)	12 (42.9)	N/A	N/A
Length of stay (days), Mean (SD)	5.4 (7.8)	4.4 (6.8) [*]	7.0 (8.9)	N/A	10 (14.0)	3.2 (3.1)	14.5 (16.4)	N/A	N/A

^aInpatients with malaria diagnosis codes as primary diagnosis.

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^bInpatients with malaria diagnosis codes as non-primary diagnosis.

^cPlasmodium species were identified based on ICD-10-CM diagnosis codes: B50.0, B50.8, and B50.9 for falciparum malaria; B51.0, B51.8 and B51.9 for vivax malaria; B52.0, B52.8 and B52.9 for malariae malaria; B53.0 for ovale malaria; B53.1 for knowlesi malaria; B53.8 for other malaria, not elsewhere classified; and B54 for unspecified malaria.

^dSome patients had multiple different malaria diagnoses and the totals shown are not mutually exclusive. Reported percentages included all patients with specified malaria diagnoses including those with multiple diagnoses.

^eThose with severe malaria were defined as having one or more of the following diagnoses or procedures: neurologic symptoms, severe anaemia with blood transfusion, renal failure, acute respiratory distress syndrome, jaundice, exchange transfusion and in-hospital death.⁴ This definition has been modified by the definition used by CDC because the MarketScan database does not fully capture information about laboratory test results or prescription drug use during hospitalization.

* Significantly different from privately insured inpatients with non-primary malaria diagnoses at $p < 0.05$.

Abbreviations: Dx, diagnosis; P-, plasmodium; SD, standard deviation; N/A, not applicable; ICD-10-CM, International Classification of Diseases Tenth revision Clinical Modification