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Original Research

Dual-Mobility Acetabular Components in Primary Total Hip Arthroplasty Do Not Increase the Risk of Complication Compared to Conventional Articulations: A Matched Cohort Comparative Analysis

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ABSTRACT

Background: A recent National Joint Registry report suggests a higher local complication risk for dual-mobility (DM) total hip arthroplasty (THA) compared to conventional articulation THA. This report may be subject to data heterogeneity with multiple confounders. Controlling for these factors by matching demographic characteristics may give different results. We aim to compare 2-year local complication rates between matched DM and conventional THAs in primary hip osteoarthritis.

Methods: Data were collected for consecutive primary THAs undertaken via a posterior approach. The conventional articulation and DM cohorts were matched 3:1 for age, gender, American Society of Anesthesiology grade, body mass index, and operative time using a propensity score and nearest neighbor matching method. Outcome measures were 2-year local complication rates, reoperation rates, systemic complication rates, and mortality rates. Demographic and outcome data were compared, and cumulative survival rates (%) were assessed using Kaplan-Meier methodology with a 2-year local complication as the endpoint. Statistical significance was set at $P < .05$.

Results: Four hundred twelve THAs were included: 309 conventional and 103 DM articulations. There were no statistically significant differences between DM and conventional articulation THAs for local complications (7 [6.8%] vs 23 [7.4%], $P = .820$), reoperations (3 [2.9%] vs 4 [1.3%], $P = .374$), systemic complications (3 [2.9%] vs 4 [1.3%], $P = .374$), or 90-day mortality (1 [1%] vs 2 [0.6%], $P = 1.000$). Kaplan-Meier survival analysis demonstrated similar 2-year survival rates for conventional THAs compared to DM THAs (93.3% [standard error, 0.014] vs 91.9% [standard error, 0.031], $P = .906$).

Conclusions: This matched study shows that there is no difference in local complication rates between DM and conventional THA articulations.

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Introduction

Total hip arthroplasty (THA) is a highly successful and cost-effective procedure for patients with end-stage hip arthritis. [1] Although complication rates are low, one of the most common reasons for revision THA is postoperative dislocation. [2] The risk of dislocation following THA varies between 2% and 5%. [3–5] After posterior capsular repair, the rate of dislocation decreases to 0%-1%. [6] Postoperative dislocation is multifactorial in nature but can be due to patient- and surgery-related risk factors. [7] Patient-related risk factors include previous hip surgery, previous trauma, poor abductor function, increasing age, neuromuscular disease, cognitive impairment, degenerative spinal disease, and drug or alcohol abuse. Surgical risk factors include surgical approach, implant design, component malpositioning, and wear or loosening of implants. The outcomes of treating dislocation following THA surgery can be unsatisfactory, and therefore prevention is better than cure. [8]

Dual-mobility (DM) acetabular components are designed to reduce the risk of postoperative dislocation following THA. [9] The DM design consists of a standard femoral head (22 mm or 28 mm)

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captured within a mobile polyethylene liner. This allows 2 moving articulations, which increases the excursion distance prior to impingement and subsequent dislocation. [10] DM bearings are often used in patients where there is a concern for postoperative instability such as patients with previous hip trauma, revision THA surgery, degenerative spinal disease, intracapsular hip fracture, neuromuscular disorder, hip dysplasia, alcohol dependency, obesity, or abnormal anatomy. [11] Several studies have confirmed a lower dislocation risk (0.46%-3.7%) with DM components for both primary and revision THA compared to conventional components. [9,12–14] However, DM components are not used in routine primary THA due to the risk of intraprosthetic dislocation, increased polyethylene wear, and increased costs. [11,12,15] Although there have been some concerns that DM THA components may theoretically lead to groin pain from the large outer bearings, the literature suggests this may not be the case in comparison with conventional THA. [16–18]

There are various types of DM components based on fixation and modularity. Cemented DM cups involve a metal shell that is cemented into host bone and articulates with a large polyethylene liner-femoral head construct. Cementless DM cups can be considered as either modular or monoblock. Modular bearings consist of a titanium shell and a separate press-fit metal aluminum liner, which are easy to use but carry an increased risk of liner malseating and corrosion in this junction, which may be a long-term problem. [19–21] Monoblock articulations (cobalt-chromium) consist of an uncemented shell with a prefitted liner. [19] Given the rigidity of the construct and the inability to attach the shell to the insertion device, these are more difficult to handle.

The National Joint Registry (NJR) of England, Wales, Northern Ireland, the Isle of Man, and Guernsey 2022 report shows a higher revision risk for DM THAs compared to conventional THAs, which is primarily due to postoperative periprosthetic femoral fracture (PFF) and periprosthetic joint infection (PJI). [3] PFF is a fracture that occurs around the femoral component of a THA. The reasons for this are unclear but may be due to increased frailty in the DM cohort, less familiarity with DM implants, and longer operating times in patients undergoing DM THA. However, it is important to acknowledge that registry-based observations may be highly prone to bias and demonstrate associative relationships rather than causative ones. Belgaïd et al. reported a low rate of PFF (1.6%) with DM cups, and a systematic literature review by Reina et al. reported PJI rates of 0.8% in DM articulations. [13,22] However, such comparisons may be inaccurate due to variations in baseline patient characteristics between the DM and conventional articulation cohorts.

Therefore, the aim of this matched cohort study is to compare clinical outcomes of DM THA and conventional THAs to determine whether this observation persists in patients with similar baseline population characteristics.

Material and methods

Following local institutional approval, data were collected via electronic health records and local Picture Archiving and Communication System radiographic software for all consecutive primary THAs between January 13, 2017, and June 16, 2020, undertaken for primary osteoarthritis (OA) via a posterior approach with a 2-year minimum follow-up in a single institution. Operative procedures were performed or supervised by multiple fellowship-trained arthroplasty consultant surgeons with a range of 8-20 years of experience. Demographic data were collected for gender, laterality, age, body mass index (BMI), and American Society of Anesthesiology (ASA) grade. Primary THA data were collected for anesthetic type (spinal, general anesthetic, or combined), operative time, THA type (cemented, cementless, hybrid, or reverse hybrid), head size, cup brand, cup type (conventional articulation or DM), stem brand, and bearing couple (metal-on-polyethylene, ceramic-on-polyethylene, or ceramic-on-ceramic). The primary outcome measure was the 2-year local complication rate. Local complications are those that occur around the operative site or as a direct result of the operation and include dislocation, PJI, PFF, intraoperative PFF, trochanteric pain syndrome, hematoma, leg length discrepancy, nerve injury, and aseptic loosening. Secondary outcome measures were length of stay, reoperation rate, systemic complication rate, and 90-day and 1-year mortality rates. Systemic complications are widespread manifestations of disease exacerbated by major surgery and include pulmonary embolism, deep vein thrombosis, myocardial infarction, acute kidney injury, electrolyte disturbance, chest infection, stroke, acute kidney injury, anemia, and heart failure.

Data for 1704 primary THAs performed for OA via a posterior approach were initially reviewed. Following matching, data for 412 THAs were included: 309 (75.0%) cases formed the conventional articulation cohort (Fig. 1), and 103 (25.0%) cases formed the DM cohort (Fig. 2). Indications for DM acetabular components were degenerative spinal disease in 59 (57.3%) cases, cognitive impairment in 14 (13.6%) cases, underlying neurological disorder in 11 (10.7%) cases, abnormal hip anatomy in 8 (7.8%) cases, alcohol abuse in 6 (5.8%) cases, and severe obesity in 5 (4.9%) cases. Acetabular components in the conventional cohort were Marathon (Depuy Synthes, MA) in 263 (85.1%) cases, ABT (Zimmer Biomet, IN) in 21 (6.8%) cases, Pinnacle (Depuy Synthes, MA) in 16 (5.2%) cases, and G7 (Zimmer Biomet, IN) in 9 (2.9%) cases. Acetabular components in the DM cohort were SERF (SERF, Wallis and Futuna, France) in 98 (67 cemented and 31 cementless monoblock articulations, 95.1%) cases and cementless modular G7 constructs in 5 (4.9%) cases. Stem brands in the conventional cohort were Exeter (Stryker, MI) in 161 (52.1%) cases, Corail (Depuy Synthes, MA) in 131 (42.4%) cases, C-stem (Depuy Synthes, MA) in 8 (2.6%) cases, Sirius (Zimmer Biomet, IN) in 5 (1.6%) cases, Taperloc (Zimmer Biomet, IN) in 3 (1.0%) cases, and Quadra (Medacta, Castel San Pietro, Switzerland) in 1 case (0.3).

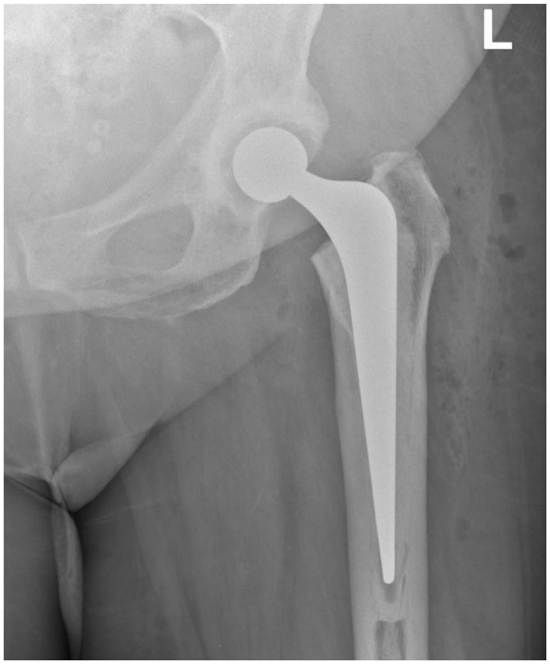

Figure 1. Conventional articulation THA radiograph.

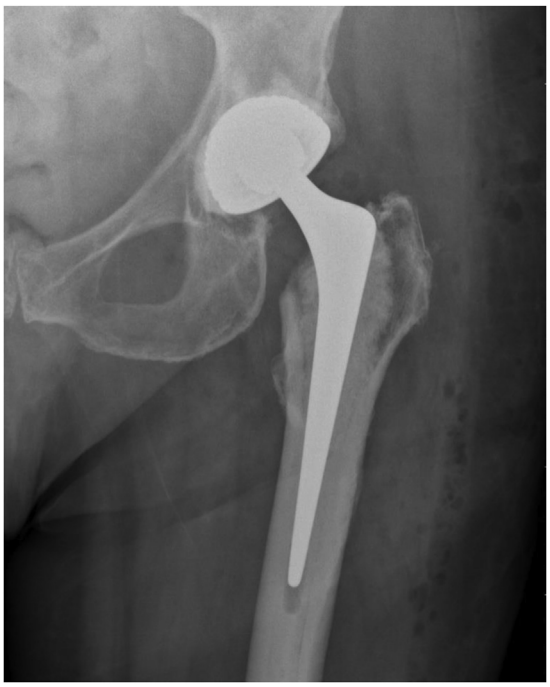

Figure 2. Dual mobility articulation THA radiograph.

Stem brands in the DM cohort were Exeter in 66 (64.1%) cases, Corail in 31 (30.1%) cases, C-stem in 3 (2.9%) cases, Sirius in 2 (1.9%) cases, and Taperloc in 1 (1.0%) case. Head sizes in the conventional cohort were 28 mm (146 [47.2%] cases), 32 mm (156 [50.5%] cases), and 36mm (7 [2.3%] cases). Head sizes in the DM cohort were 22 mm (18 [17.5%] cases) and 28 mm (85 [82.5%] cases).

Statistical analyses were performed using the R (v3.6.1, R, Vienna, Austria) software package. The conventional articulation and DM cohorts were matched 3:1 for age, gender, ASA grade, BMI, and operative time using a propensity score and nearest neighbor matching method. Patients were 3:1 matched to ensure the sample of the control group was as representative of the population as possible, given the large database of patients in the unit. Parametricity was assessed using a Kolmogorov-Smirnov test. Demographic and outcome data were compared using the chi-square and Mann-Whitney *U*-tests, and where assumptions for these were not met, the Fisher's exact test. Cumulative survival rates (%) with standard error (SE) were assessed using Kaplan-Meier methodology with a 2-year local complication as the endpoint. Patients who died before the end of the study period were censored. Log rank statistic was used to compare treatment methods. Statistical significance was set to $P < .05$.

Results

Comparison of baseline characteristics between the 2 matched cohorts is presented in Table 1. There were statistically significant differences between the cohorts for THA type ($P < .001$) and length of follow-up, with a median of 3.9 (interquartile range [IQR] 3.0-4.8) years in the conventional cup as opposed to a median of 2.1 (IQR 2.6-4.5) years in the dual mobility group ($P = .003$). In the dual mobility group, there were 48 (46.6%) cemented, 14 (13.6%) cementless, 22 (21.4%) hybrid, and 19 (18.4%) reverse hybrid implants. Comparatively, the conventional articulation group utilized 168 (54.4%) cemented, 21 (6.8%) cementless, 6 (1.9%) hybrid, and 114 (36.9%) reverse hybrid implants. All patients were accounted for with no loss of follow-up. Twelve (2.9%) patients died before the end of the study period.

Table 1
Comparison of baseline characteristics.

Variable	Conventional (n, %)	Dual mobility (n, %)	*P*-value
Total (412)	309 (75.0)	103 (25.0)	
Men (patients)	107 (34.9)	35 (34.3)	.921
Right sided	155 (50.2)	53 (51.5)	.820
Follow-up (years, median, IQR)	3.9 (3.0-4.8)	2.1 (2.6-4.5)	.003[a]
Age (years, median IQR)	73.2 (64.4-80.5)	75.0 (63.2-81.1)	.641
Body mass index (BMI)	27.7 (23.9-31.9)	34.2 (23.9-32.2)	.391
ASA grade			.337
1	19 (6.1)	3 (2.9)	
2	170 (55.0)	60 (58.3)	
3	115 (37.2)	40 (38.8)	
4	5 (1.6)	0 (0.0)	
Anesthetic type			.884
Spinal	161 (52.1)	55 (53.4)	
General anesthetic	129 (41.7)	43 (41.7)	
Combined	19 (6.1)	5 (4.9)	
Operative time (mins)	71.0 (57.8-84.0)	68.6 (57.3-89.9)	.916
THA type			<.001[a]
Cemented	168 (54.4)	48 (46.6)	
Cementless	21 (6.8)	14 (13.6)	
Hybrid	6 (1.9)	22 (21.4)	
Reverse hybrid	114 (36.9)	19 (18.4)	
Bearing couple			.074
MoP	250 (80.9)	91 (88.3)	
CoP	47 (15.2)	12 (11.7)	
CoC	12 (3.9)	0 (0.0)	

THA, total hip arthroplasty; MoP, metal-on-polyethylene; CoP, ceramic-on-polyethylene; CoC, ceramic-on-ceramic.
[a] Statistically signficant results.

There were no statistically significant differences between matched groups for local complications: 7 (6.8%) in DM vs 23 (7.4%) in conventional articulations ($P = .820$); time to local complication, with a median of 819 days (IQR 138-756) in DM and 127 (IQR 57-504) in conventional ($P = .396$); reoperations, 3 (2.9%) in DM and 4 (1.3%) in conventional ($P = .374$); systemic complications, 3 (2.9%) in DM and 4 (1.3%) in conventional ($P = .374$); time to systemic complication, with a median of 631 days (IQR 5-635) in DM and 2 days (2.5-23.5) in the conventional group ($P = .858$). Nor were there significant differences in 90-day mortality, with 1 death in DM (1%) and 2 (0.6%) in conventional articulations ($P = 1.000$); or 1-year mortality, with 1 death in DM (1%) and 8 (2.6%) in conventional ($P = .461$). Dual mobility articulations had a significantly longer length of stay ($P = .003$), staying a median of 4 (IQR 2-6) days compared to 3 (IQR 2-4) days in the conventional group, and time to reoperation ($P = .034$), with DM articulations taking a median of 428 days (IQR 682-1084) to reoperation compared to conventional cups taking 29 days (IQR 8-52). Overall, there were 30 local complications with 2 patients sustaining 2 complications each. There were no statistically significant differences between the groups for each of the local complications experienced. These data are further detailed in Tables 2 and 3. Kaplan-Meier survival analysis demonstrated similar 2-year survival rates for conventional THAs compared to DM THAs (93.3% [SE, 0.014] vs 91.9% [SE, 0.031], $P = .906$, Figure 3). Between modular, monoblock, and cemented articulations, the number of patients in each group and complications were too low to perform any meaningful statistical comparison; therefore, the data has been analyzed descriptively. The single dislocation (1%) occurred in the cementless modular articulation. The PJI (1%) and PFF (1%) occurred with the cemented acetabular constructs. Trochanteric pain syndrome occurred in 2 cemented constructs (1.9%) and 1 uncemented monoblock articulation (1%). A single case (1%) of leg length discrepancy occurred in the cemented group.

Table 2
Comparison of outcomes.

Variable	Conventional (n, %)	Dual mobility (n, %)	*P*-value
Total (412)	309 (75.0)	103 (25.0)	
Length of stay (days, median, IQR)	3 (2-4)	4 (2-6)	.003[a]
Local complications	23 (7.4)	7 (6.8)	.820
Time to local complication (days, median, IQR)	127 (57-504)	819 (138-756)	.396
Reoperations	4 (1.3)	3 (2.9)	.374
Time to reoperation (days, median, IQR)	29 (8-52)	428 (682-1084)	.034[a]
Systemic complications	4 (1.3)	3 (2.9)	.374
Time to systemic complication (days, median, IQR)	2 (2.5-23.5)	631 (5-635)	.858
Mortality			
90-d	2 (0.6)	1 (1.0)	1.000
1 y	8 (2.6)	1 (1.0)	.461

[a] Statistically signficant results.

Discussion

This matched cohort study compared the local and systemic complications at 2-years with the use of DM THA compared to conventional articulation THA in a matched series of patients undergoing THA for primary OA through a posterior approach. It confirms that DM THA does not result in an increased complication or reoperation rate compared to conventional articulation THA. Specifically, we did not observe a higher rate of PFF or PJI in the DM cohort.

This study demonstrates a low local complication rate in both cohorts with no significant differences between the groups. Existing literature has shown a dislocation rate of 0%-12.9% for primary DM THA, where we have demonstrated a risk of 1%. [9,23] Of the 3 patients who underwent reoperations in the DM cohort, 1 (0.97%) was for dislocation, 1 (0.97%) for PJI, and 1 (0.97%) for PFF. The NJR Prosthesis Time Incident Rate for revision of DM THAs for PJI is 1.38%-2.75%, for PFF it is 1.39%-2.58%, and for dislocation it is 1.15%-1.73%. [3] The Prosthesis Time Incident Rate expresses the number of revisions divided by the total of the individual prosthesis years at risk and is usually expressed per 1000 years at risk. Comparatively, our findings show a lower risk of reoperation for these indications. Aseptic loosening is reported as 1 of the most common indications for revision of a DM implant. [24] We have not experienced this complication in our cohort, although our follow-up period would be too short to pick it up. Both length of stay and time to reoperation were significantly increased in the DM cohort. The reasons for this are unclear but may be related to the study sample size.

The main finding in this study was that DM acetabular components were not associated with an increased risk of local complications such as PJI or PFF, as reported by the NJR. The NJR reports on all cases entered into the database following primary and revision THA, and therefore absolute comparisons are subject to bias because confounding factors are not incorporated into any comparative analysis. This study has accounted for a number of confounding factors by comparing matched cohorts and therefore reduces the risk of bias during comparisons of DM and conventional articulation THA. Both PJI and PFF have multifactorial etiologies that cannot be solely attributed to the type of acetabular component present at primary THA. It is also unclear how DM acetabular components might increase the risk of PFF, particularly as these are less constrained and offer greater range of motion prior to neck-rim impingement than conventional acetabular components. [9] Similarly, longer operative times with DM THA may be associated with a higher risk of PJI; however, our study refutes that hypothesis as we have matched for this confounding factor. Furthermore, centers with a high-volume DM THA practice may observe little difference in operative time due to increased familiarity with these implants. Owing to the low overall local complication rates, we are unable to comment on any specific trends of cemented vs cementless cups that may influence surgical practice. This study consisted of a heterogeneous group of implants; however, this diversity reflects current practice. A more detailed risk analysis using a multivariate logistic regression model would be appropriate in determining whether an increased risk of complication actually exists across multiple centers, although this would require a much larger sample size for meaningful analysis. It must be noted that complications and reoperation rates are short-term outcomes. Importantly, long-term outcomes such as wear and loosening should be incorporated into future analyses to fully appreciate the efficacy of DM constructs in primary hip arthroplasty.

We included only patients operated on through a posterior approach, as this is the prevailing approach used by the majority of arthroplasty surgeons in the UK. By excluding other approaches, this reduces the confounding effect of surgical approach on outcomes such as dislocation. DM components were also developed primarily for the posterior approach due to greater access and

Table 3
Local complications.

Variable	Conventional (n, %)	Dual mobility (n, %)	*P*-value
Dislocation	2 (0.6)	1 (1.0)	1.000
Prosthetic joint infection	2 (0.6)	1 (1.0)	1.000
Postoperative periprosthetic femoral fracture	0 (0.0)	1 (1.0)	.250
Intraoperative periprosthetic femoral fracture	1 (0.3)	0 (0.0)	1.000
Trochanteric pain syndrome	14 (4.5)	3 (2.9)	.579
Hematoma	2 (0.6)	0 (0.0)	1.000
Nerve injury	1 (0.3)	0 (0.0)	1.000
Aseptic loosening	1 (0.3)	0 (0.0)	1.000
Leg length discrepancy	0 (0.0)	1 (1.0)	.250

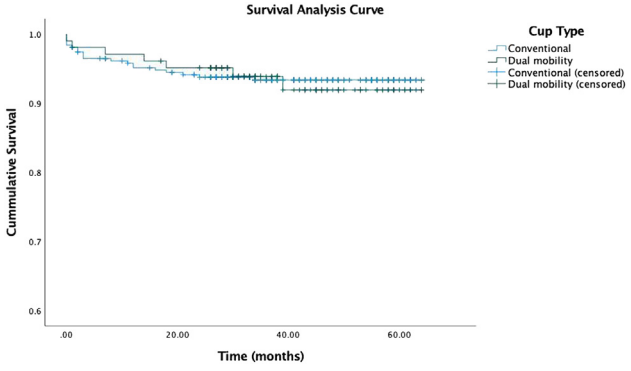

Figure 3. Kaplan-Meier survival analysis curve.

exposure to the hip joint compared to other approaches. [25] DM implants may have less of a role than anterior approaches, which are considered to have a lower dislocation rate. However, the literature is inconclusive, as the posterior approach has not consistently been associated with an increased dislocation risk. [15]

The major strength of this study includes comparing matched cohorts to reduce the effect of confounding variables. We matched patients for age, gender, BMI, ASA, and also operative time. There is a direct correlation between these factors and the risk of local complication such as PJI and PFF. [26,27] We only investigated THAs performed for primary OA, so cannot extrapolate our findings for DM THAs performed for other indications, such as hip fracture—primary or postfailed internal fixation. Indications for DM included spinal deformity, neurological impairment, abnormal anatomy, alcohol use, cognitive impairment, and severe obesity. A limitation of this study was that this data was not consistently available for the conventional articulation group. Key differences would have been expected regardless, given the use of DM in high-risk patients, and patients were matched for BMI. A further limitation of the study is the lack of a functional outcome measure, which is required for a more holistic assessment. Expected and unavoidable differences were observed between the groups. The DM cohort had a shorter overall follow-up period as this implant type was a relatively recent introduction to the unit in order to prophylactically prevent dislocation in high-risk patients. There was also a higher rate of reverse hybrid THA observed in the conventional THA cohort, and this reflects an older practice within our unit. In keeping with national trends in THA fixation in the UK, there has been a gradual shift toward more hybrid THAs. It is unlikely that these differences in THA type affected our results.

Conclusions

This matched cohort study of DM THA confirms low rates of local complication, including dislocation, PFF, and PJI, which are comparable to conventional THA articulations. This study's results are in contrast to those reported by NJR, emphasizing the necessity of controlling for confounding factors when interpreting registry data.

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Conflicts of interest

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CRediT authorship contribution statement

Mehnoor Khaliq: Writing — review & editing, Writing — original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Neesha Jenkins:** Data curation. **Bernard Van Duren:** Writing — review & editing, Writing — original draft, Methodology, Formal analysis. **Jeya Palan:** Writing — review & editing, Supervision. **Hemant Pandit:** Writing — review & editing, Writing — original draft, Supervision, Resources, Funding acquisition. **Sameer Jain:** Writing — review & editing, Writing — original draft, Supervision, Methodology, Formal analysis, Conceptualization.

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