Inequitable Access: Factors Associated with Incomplete Referrals to Pediatric Cardiology

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Abstract

Objective: To assess the variables associated with unscheduled and incomplete cardiology clinic visits among referred pediatric patients with a focus on equity gaps.

Study Design: We conducted a retrospective chart review for patients less than 18 years of age who were referred to cardiology clinics at a single quaternary referral center from 2017 to 2019. We collected patient demographic data including race, an index of neighborhood socioeconomic deprivation linked to a patient's geocoded address, referral information, and cardiology clinic information. The primary outcome was an incomplete clinic visit. The secondary outcome was an unscheduled appointment. Independent associations were identified using multivariable logistic regression.

Results: There were 10,610 new referrals; 6,954 (66%) completed new cardiology clinic visits. Black race (OR 1.41; 95% CI 1.22-1.63), public insurance (OR 1.29; 95% CI 1.14-1.46), and a higher deprivation index (OR 1.32; 95% CI 1.08-1.61) were associated with higher odds of incomplete visit compared to the respective reference groups of White race, private insurance, and a lower deprivation index. The findings for unscheduled visit were similar. A shorter time elapsed from the initial referral to when the appointment was made was associated with lower odds of incomplete visit (OR 0.62; 95% CI 0.52-0.74).

Conclusion: Race, insurance type, neighborhood deprivation, and time from referral date to appointment made were each associated with incomplete referrals to pediatric cardiology. Interventions directed to understand such associations and respond accordingly could help to equitably improve referral completion.

Introduction

Referral to a subspecialty service is a common and necessary occurrence in pediatrics. Referrals represent a request for expertise outside the scope of the referring physician for assistance with diagnosis or management of certain conditions or concerns [1]. One-fifth of pediatric patients are referred to subspecialists annually [2]. The utility of the referral is dependent on completion of the appointment with the subspecialist. Incomplete referrals, those referrals that never result in a visit, are quite common. Of all referrals made to subspecialty clinics among pediatric patients, an estimated 20–50% are incomplete, with substantial variation across subspecialties [3–5].

The American Academy of Pediatrics recommends that pediatric patients in need of subspecialty care should be seen by a pediatric subspecialist [6]. And yet, there are several challenges associated with the referral process that have been described in the literature [7]. Longer wait times and farther distance to in-network subspecialists each decrease the odds of scheduling referral appointments (thereby increasing the rate of incomplete referrals) [8]. Among pediatric patients, lower perceived necessity by both caregiver and primary care provider is associated with lower referral completion rate [9]. Challenges including scheduling appointments in a timely manner, inconvenient clinic hours, and difficulty finding clinic locations have also been correlated with higher likelihood of an incomplete referral [4]. On the other hand,

factors associated with referral completion include younger patient age, private insurance status, and residence within zip codes with higher median income [5].

There are racial and socioeconomic gaps in medical outcomes across subspecialties, including cardiology. It is well documented that Black adults have higher odds of cardiovascular disease and mortality compared to their White peers [10]. Socioeconomic status has also been shown to play a large part in prevalence of out-of-hospital cardiac arrest and cardiovascular disease mortality [11, 12]. Within pediatrics, there is a growing body of evidence demonstrating worse congenital heart disease outcomes for infants who are born to mothers identifying as Black, Hispanic, and Asian/Pacific Islander compared to those identifying as non-Hispanic White. Similarly, those living in neighborhoods with higher poverty rates have suboptimal outcomes compared to those living in neighborhoods with lower poverty rates. These racial and socioeconomic inequities likely emerge from structural factors rooted in differential social determinants of health [13–18].

It is possible that incomplete referrals, and missed opportunities for the provision of subspecialty services, could negatively affect the patient experience and influence the presence and magnitude of equity gaps in outcomes. While acknowledging that the true positive rate of disease in patients referred to cardiology clinics for common complaints such as chest pain, syncope, and murmur is low,[19–21] such symptoms burden patients and their families and referral completion could enhance quality-of-life. Equitable referral completion could do so in ways that narrow gaps [22]. Still, there has been limited research in pediatrics to evaluate the drivers of incomplete referrals within individual specialties, including pediatric cardiology. Therefore, the objective of this study was to evaluate the variables associated with incomplete referrals, and inequities in incomplete referrals, among patients referred to pediatric cardiology subspecialty clinics at a quaternary pediatric referral center.

Materials And Methods

Study design and population:

We performed a retrospective chart review using data from the Cincinnati Children's Hospital Medical Center (CCHMC) pediatric cardiology division. The local institutional review board reviewed and approved this study prior to collecting data. Patients were eligible for inclusion in the dataset if they were referred to pediatric cardiology between January 1, 2017, and December 31, 2019. Referrals were placed by a primary care or subspecialist provider. Eligible patients had to be less than 18 years of age at the time of referral. Patients referred to cardiology within the preceding 3 years were excluded. Patients with missing race/ethnicity, gender, language, health insurance type, and address were also excluded. During the study period, there were no significant changes to the referral process or clinic structure.

Setting:

CCHMC's pediatric cardiology division operates both general pediatric cardiology and cardiology subspeciality clinics. The primary service area for CCHMC is the Cincinnati metropolitan area. This

includes Cincinnati's urban core as well as suburbs and rural areas in Southwest Ohio, Northern Kentucky, and Southeast Indiana. CCHMC cardiology clinics are located throughout the primary service area. There are approximately 23,000 patients seen each year in CCHMC cardiology clinics. CCHMC outpatient cardiologists are predominantly White. Referrals can be placed electronically or via fax by a primary care provider or subspecialist provider. Whenever a referral is placed, cardiology staff members call the referred family. If contact is not made on the first call, two additional calls are made over a period of several days. Appointments can be scheduled via these phone calls. For all CCHMC primary care and subspecialty clinics, wait time is measured using the number of days required to find the 3rd next available appointment. Wait times for CCHMC's general cardiology clinics had a mean 3rd next available appointment of 1.1 days during the study period. However, some of the cardiology subspecialty clinics had wait times that were considerably longer. For example, the time to the 3rd next available appointment was 18.5 days for the hypertension clinic and 44.8 days for the preventative cardiology clinic during the study period.

Key outcome and predictor variables:

The primary outcome variable was an incomplete visit following referral to any of the cardiology clinics. Patients were defined as having an incomplete visit if they were referred but never attended a clinic visit, regardless of whether the visit was scheduled. The secondary outcome was an unscheduled appointment. Patients were defined as having an unscheduled appointment if they were referred but never scheduled an appointment. The outcomes were evaluated up until the time of data collection, giving each patient a minimum of two months to schedule and complete their visit before having their visit considered incomplete. Patients were classified as having an appointment scheduled or not scheduled. Of those that were scheduled, they were further classified according to having complete or incomplete visits. We also classified patients as having a complete or incomplete visit regardless of schedule status (Online Resource 1).

We evaluated the association between a variety of factors and unscheduled/incomplete referral visits. Patient level variables included age, race/ethnicity, gender, language, health insurance type, address, and time from referral to appointment (if one was scheduled). These data were all accessible from within the electronic health record. Age was categorized using the distribution among all of those referred, splitting the sample into quantiles. We combined race and ethnicity into a single variable given the ways these variables are assessed across CCHMC and documented within the electronic health record. Race/ethnicity was categorized as Asian, Black, Hispanic/Latino, and White. Gender was classified as male or female. Language was categorized as English, Spanish, or Other. Health insurance was categorized as Private or Public. The patient's address was geocoded and located to a specific census tract geography and related socioeconomic data. Specifically, we used a widely available, open-source, validated socioeconomic deprivation index (DI). The DI is calculated from census tract-level median household income, fraction of households below the poverty level, fraction of those 25 years and older with at least a high school degree/GED, fraction with insurance, fraction receiving public assistance, and fraction of housing units that are vacant [23]. The DI ranges from 0 to 1 with higher values

representing higher levels of deprivation [23]. Census tracts are smaller statistical subdivisions of a county and provide for a more homogeneous population than zip codes allowing for improved study of socioeconomic determinants of health [24,25]. For our analyses, the DI values of comparison were the national mean of 0.38 (slightly higher than our study median of 0.35) and the median of the 5% of patients in our sample living in the most deprived census tracts. We chose to compare the national mean with the most deprived to evaluate the impact of more extreme levels of deprivation on referral completion. For patients in our study living in a census tract with a DI of 0.38, the median income was $45,000, the poverty level was 15%, and 11% of the population did not have health insurance. For patients in our study living in a census tract with a DI of 0.66 (the most deprived 5%), the median income was $23,000, the poverty level was 48%, and 24% of patients did not have health insurance.

Additional variables included reason for referral and season in which the referral was made. The reason for referral was determined via manual review of the chart by a pediatric cardiologist. We grouped reasons for referral into categories capturing the most common reasons for referral. Categories included abnormal echocardiogram/fetal imaging, abnormal electrocardiogram (EKG), evaluations for cardiomyopathy, chest pain, congenital heart disease, cyanosis, dizziness/syncope, preventative cardiology, exercise intolerance/dyspnea, family history, genetic diagnosis, and palpitations (Figure 1). The genetic diagnosis category included those patients with a known or suspected genetic diagnosis that has increased risk of cardiovascular structural abnormalities or disease. Preventative cardiology included referrals for elevated blood pressures, elevated lipids, and obesity or other metabolic conditions that increase risk of heart disease. The family history category included any patient with concerning family cardiac history including sudden cardiac death, arrythmias, ischemic heart disease, and structural abnormalities. Family history of cardiomyopathy, however, was included in the cardiomyopathy category only. If there were multiple referral reasons, the first documented referral reason was used to categorize the referral. Season for referral was grouped into three-month blocks in which the weather conditions are similar for each month in a given block (i.e. December to February in this region is typically cold with occasional snow/ice precipitation).

Statistical Analysis:

Medians with interquartile ranges (IQR) for continuous variables (DI and age), and frequencies for categorical variables were calculated for patient demographic and referral information variables. Bivariate analyses were performed to evaluate differences between patients with complete and incomplete referral visits and patients with scheduled and unscheduled appointments. This was done using the Wilcoxon rank-sum test for continuous variables or chi-square test for categorical variables. Separate multivariable logistic regression models were fitted for incomplete referral clinic visits and unscheduled visits using the lrm function in the rms package in R.[26] Model predictors included age, race/ethnicity, gender, language, health insurance type, DI, days from referral to appointment scheduled, referral reason, and season of referral. We allowed for potential non-linear associations for age at referral and DI via the inclusion of restricted cubic spline terms (four knots placed at the 5th, 35th, 65th, and 95th percentiles). The probability of unscheduled visit or incomplete referral according to predictors were

obtained from the model estimates. Interactions were assessed between predictors; given the lack of significance of such interactions, we opted to remove them from subsequent models. Model discrimination was further measured by the concordance index (c-index). A c-index of value 1 reflects perfect discrimination, whereas 0.5 reflects random prediction. P values less than 0.05 were considered statistically significant. All statistical analyses were performed using R (version 3.6.1) [27].

Results

There were 12,440 new referrals to CCHMC pediatric cardiology clinics during the three-year study period. After excluding those with missing variables, there were 10,610 new referrals remaining (Figure 2). Most referrals, 8,767 (83%), resulted in a scheduled appointment. Among all referrals, including both those with a scheduled and an unscheduled appointment, 6954 (66%) resulted in a completed cardiology clinic visit. Among all scheduled visits, 79% resulted in a completed visit. The median time from when the referral was placed to when the appointment was scheduled was 20 days (IQR 9-37); two-thirds (67%) were scheduled within the first 30 days.

The median age of those referred was 9 years (Table 1). Most referrals were for patients who self- or caregiver-identified as White (76%), followed by Black (19%), and Hispanic/Latino (3.2%). This is similar to the racial and ethnic breakdown of Greater Cincinnati[28]. English was the most common language among those referred (97%). Slightly over half of patients had private insurance (54%) while the remainder had public insurance (46%). The most common referral season was June to August (29%). Most of the referrals were for children living within the primary service area (71%). The most common reason for referral was heart murmur (33%).

Bivariate analysis

In the group of patients that did not schedule an appointment, there was a higher proportion of Black patients (27% vs. 17%, $p < 0.001$, Table 2) and patients with public insurance (52% vs. 45%, $p < 0.001$) compared to those who scheduled an appointment. Among all scheduled patients who did not complete their referral visit there was a higher proportion of Black patients (23% vs. 15%, $p < 0.001$, Table 3), patients with public insurance (53% vs. 43%, $p < 0.001$), and patients referred for preventative cardiology (16% vs. 12%, $p < 0.001$) compared to those who scheduled appointments and completed their cardiology referral visit.

Regression model for unscheduled appointments

A multivariable logistic regression model was fit to obtain predicted probabilities and ORs for unscheduled appointments. The overall likelihood-ratio chi-square statistic was 567.12 (degree of freedom = 29 and $P<0.001$), and the c-index of the model was 0.67. Black patients who were referred to cardiology were more likely to have an unscheduled appointment (OR 1.66; 95% CI 1.44-1.90, Table 2) while Hispanic/Latino patients were less likely to have an unscheduled appointment (OR 0.63; 95% CI 0.40-0.98) than White patients. Patients with public insurance were more likely to have an unscheduled

appointment compared to those with private insurance (OR 1.37; 95% CI 1.21-1.54). There was no clear association between unscheduled appointments and socioeconomic deprivation up to the DI of the national mean (0.38), however; patients with a higher DI of 0.66 (the top 5th% most deprived) compared to the national mean had increased odds of having an unscheduled appointment (OR 1.22; 95% CI 1.00-1.48, Table 3 and Figure 3)

Compared to a referral for heart murmurs, cardiomyopathy evaluations (OR 3.87; 95% CI 2.65-5.65), chest pain (OR 1.26; 95% CI 1.02-1.58), congenital heart disease (OR 1.69; 95% CI 1.26-2.27), dizziness/syncope (OR 1.55; 95% CI 1.24-1.94), family history (OR 2.56; 95% CI 1.97-3.33), genetic diagnosis (OR 2.09; 95% CI 1.55-2.83), and preventative cardiology (OR 2.91; 95% CI 2.43-3.47) each were associated with higher odds of unscheduled appointments.

Regression model for incomplete visits

A separate multivariable logistic regression model was fit to assess incomplete referral clinic visits as the outcome of interest. The overall likelihood-ratio chi-square statistic was 350.10 (degree of freedom =34, $p < 0.001$), and the c-index of the model was 0.64. Black patients (OR 1.41; 95% CI 1.22-1.63, Table 3) were more likely than their White peers to not complete their cardiology subspecialty referral. Patients with public insurance (OR 1.29; 95% CI 1.14-1.46) had higher odds of an incomplete referral compared to those with private insurance. Patients living in the most socioeconomically deprived census tracts (DI of 0.68, most deprived 5%) were more likely to not complete their visit compared to those living in census tracts at or below the national deprivation mean (DI of 0.38) (OR 1.32; 95% CI 1.08-1.61). The association between DI and incomplete visit is demonstrated in Figure 4.

Appointments scheduled within the first seven days of the referral being made were less likely to have an incomplete visit (OR 0.62; 95% CI 0.52-0.74) and those taking longer than 30 days to schedule an appointment were more likely to have an incomplete visit compared to those scheduling an appointment within 15-30 days of the referral being placed. Referrals placed from December-February were more likely to have an incomplete visit compared to the reference season of June-August (OR 1.20; 95% CI 1.03-1.39).

Among the referral reasons, abnormal fetal imaging/echocardiogram (OR 1.62; 95% CI 1.09-2.38), chest pain (OR 1.27; 95% CI 1.01-1.56), congenital heart disease (OR 1.60; 95% CI 1.22-2.08), genetic diagnosis (OR 1.93; 95% CI 1.44-2.60), and preventative cardiology (OR 1.42; 95% CI 1.17-1.73) were associated with higher odds of incomplete referral visits compared to the reference referral reason of murmur.

Discussion

In this quaternary care pediatric cardiology referral center, 83% of patients who were referred scheduled an appointment; just 66% of patients completed their referral. The completed referral rate was within the range that has previously been described among pediatric patients referred to cardiology; although, our

population size is significantly larger [3, 5]. We found that there were multiple patient and system level variables associated with unscheduled and incomplete cardiology clinic visits.

Patient level variables that were found to be independently associated with unscheduled referral and incomplete visit included Black race and public insurance. This has been established previously in pediatric referrals but not specifically within cardiology [3, 5, 29]. Long standing exploitation of Black Americans by the medical system has fostered mistrust in the health care system [30]. The confluence of mistrust with structural impediments to receipt of health care services disproportionately experienced by minoritized communities is likely influencing this finding [31, 32]. While the research is mixed regarding the effect of patient-provider race, gender, and language concordance on care experiences and clinical outcomes, there has been some evidence that concordance improves patient experience and outcomes [33–37]. A lack of cardiologists of color at this institution could similarly influence referral completion rate, although it is unlikely that referred patients are aware of the racial/ethnic breakdown of outpatient cardiologists prior to their first visit.

We also found that higher levels of neighborhood socioeconomic deprivation were associated with unscheduled and incomplete visit. To the best of our knowledge, this has not been previously studied among referred patients to pediatric cardiologists. These findings come at a time when there are growing calls to ensure equitable health care for marginalized populations, including those affected by racial and socioeconomic segregation and discrimination [38, 39]. Future efforts to evaluate the barriers mostly commonly encountered by the aforementioned populations to develop targeted interventions and possibly reduce rates of incomplete referral. Moreover, for families struggling to pay rent or put food on the table, an abstract cardiology concern may be a lower priority.

Indeed, competing priorities, rigid work schedules, and transportation challenges all could decrease the ability to schedule and attend an appointment. These factors could also be targets for interventions poised to equitably improve outcomes. For example, alternative approaches to care provision may make sense should transportation emerge as a consistent barrier, as might be suggested by higher rates of incomplete referral during winter months when driving conditions in the service area are more challenging. We are experimenting with the use of a mobile care van and telemedicine, strategies becoming more common in cardiology [40, 41]. E-stethoscope use, in combination with telemedicine, has also proven feasible and may be relevant in the evaluation of certain referral reasons (e.g., murmur in a low-risk patient) [42–44]. Revising the referral process itself might also reduce incomplete visit rates. Prior, just three phone calls were made to the referred patient's family before outreach attempts cease. If a parent works third shift or long hours without breaks during the day, answering calls during business hours may prove impossible. Pursuing a model that triages referrals based on potential or identified risk factors (e.g., living in deprived community, limited transportation options, rigid work schedule) could expedite different outreach strategies. Using the results of this study, we have since revised the referral process by sending an email and letter to referred patients if they do not answer the initial phone calls. They are now also able to schedule appointments via email. Of course, we certainly do not have all the answers. Future qualitative studies including interviews with families who were unable to schedule or

attend their visit may help to determine reasons why visits are not completed. Co-production, that is, identifying solutions with end stakeholders may lead to meaningful, sustainable improvements.

Referrals where a visit was scheduled within 7 days of the referral being placed were associated with lower odds of an incomplete visit. This finding has been previously demonstrated [5]. This could be caused by higher parental concern or higher acuity/need for cardiology referral. Implementing a process of online referrals with the ability to make an immediate appointment improves attendance of subspeciality clinic visits[45]. However, blanket implementation of certain interventions, particularly those that involve use of technological innovations, could worsen inequities present in subspecialty access to care [46]. A careful and targeted roll out of any intervention would be necessary to track visit completion overall and for marginalized populations.

Among the reasons why patients were referred to our pediatric cardiology clinics, chest pain, congenital heart disease, preventative cardiology, and genetic diagnosis all were linked to higher odds of unscheduled appointments and incomplete visits compared to those referred for murmur. Cardiomyopathy and dizziness/syncope clinics had higher odds of unscheduled visits but no difference in the rate at which appointments were completed. There were no data collected from individual referrals on reasons why an appointment was not scheduled or attended. In adults, it has been shown that patients who believed their health problem was resolved could lead to higher odds of incomplete referral [29]. This situation is also possible in our population. For example, if a patient is referred for chest pain and the pain resolves prior to making or completing an appointment, chances are the referral will be incomplete.

Adults and children that have a longer wait times until their appointment are less likely to complete their referral [8, 9]. As previously discussed, general cardiology clinics at our institution have shorter mean wait times than subspecialty clinics. This is one possible explanation for why patients referred to preventative cardiology (mean 3rd next available appointment time 44.8 days) had higher odds of unscheduled visit and incomplete referral. Preventative cardiology could have higher incomplete referrals due to differences in perception of the relative importance of the health problem between the referring provider and the referred patient/family which has been previously associated with lower rates of referral completion.[9] Alternatively, the fear of potential bad news or a negative outcome could affect rates of incomplete referrals for some conditions or chief complaints. For example, parents and adolescent children might fear that attending their cardiology referral visit for chest pain could lead to a need to limit participation in sports. Further research seeking out the parent/patient perspective on unscheduled or incomplete visits could illuminate specific barriers or challenges and inform innovative, equitable care models.

The results of this study should be evaluated with an understanding of its limitations. First, this study was conducted in a retrospective manner at a single center. This means that any linkages identified represent association and not causation. Also, there might be geographic, institutional, and specialty differences that limit applicability of the results to other institutions or to other pediatric specialties. Second, the electronic health record data at our disposal did not allow for the determination of why a visit

was not scheduled or not attended. For instance, we did not know the parental work schedule, transportation access, distance from the cardiology office to clinic location where the visit would take place, or number of caregivers living within the household. Third, we categorized referrals based on the first reasons for which they were referred if there were multiple reasons for the referral. Therefore, overlap between the different referral reasons may limit the ability to interpret the impact of referral reason on completed cardiology visits. Fourth, the data collection occurred 2 months after last referral was placed and therefore might limit the ability of those referred in the last month to complete their visit.

Conclusion

Patient and system level variables are associated with the rate of cardiology subspecialist referral completion. We need further research to elucidate how we can help our patients more easily complete referrals and receive subspecialty care in equitable ways.

Declarations

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Ethics approval: Ethical approval was obtained from the Cincinnati Children's Hospital Institutional Review Board and the research activities were determined to be exempt.

Author Contributions

Study conception and design was performed by Paul Warren, Huaiyu Zang, Christopher Statile and Jeffrey Anderson. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was written by Paul Warren and all authors commented on subsequent versions of the manuscript. All authors read and approved the final manuscript.

References

1. Forrest CB (2009) A typology of specialists' clinical roles. Arch Intern Med 169: 1062–1068
2. Forrest CB, Majeed A, Weiner JP, Carroll K, Bindman AB (2003) Referral of children to specialists in the United States and the United kingdom. Arch Pediatr Adolesc Med 157: 279–285

3. Zuckerman KE, Cai X, Perrin JM, Donelan K (2011) Incomplete specialty referral among children in community health centers. J Pediatr 158: 24–30
4. Zuckerman KE, Perrin JM, Hobrecker K, Donelan K (2013) Barriers to specialty care and specialty referral completion in the community health center setting. J Pediatr 162: 409–414.e401
5. Bohnhoff JC, Taormina JM, Ferrante L, Wolfson D, Ray KN (2019) Unscheduled Referrals and Unattended Appointments After Pediatric Subspecialty Referral. Pediatrics 144:
6. Basco WT, Rimsza ME, Workforce CoP, Pediatrics AAo (2013) Pediatrician workforce policy statement. Pediatrics 132: 390–397
7. KUNKLE EC (1964) COMMUNICATION BREAKDOWN IN REFERRAL OF THE PATIENT. JAMA 187: 663
8. Patel MP, Schettini P, O'Leary CP, Bosworth HB, Anderson JB, Shah KP (2018) Closing the Referral Loop: an Analysis of Primary Care Referrals to Specialists in a Large Health System. J Gen Intern Med 33: 715–721
9. Zuckerman KE, Nelson K, Bryant TK, Hobrecker K, Perrin JM, Donelan K (2011) Specialty referral communication and completion in the community health center setting. Acad Pediatr 11: 288–296
10. Van Dyke M, Greer S, Odom E, Schieb L, Vaughan A, Kramer M, Casper M (2018) Heart Disease Death Rates Among Blacks and Whites Aged ≥ 35 Years - United States, 1968–2015. MMWR Surveill Summ 67: 1–11
11. Jonsson M, Ljungman P, Härkönen J, Van Nieuwenhuizen B, Møller S, Ringh M, Nordberg P, ftE-Ni (2020) Relationship between socioeconomic status and incidence of out-of-hospital cardiac arrest is dependent on age. J Epidemiol Community Health 74: 726–731
12. Timmis A, Townsend N, Gale CP, Torbica A, Lettino M, Petersen SE, Mossialos EA, Maggioni AP, Kazakiewicz D, May HT, De Smedt D, Flather M, Zuhlke L, Beltrame JF, Huculeci R, Tavazzi L, Hindricks G, Bax J, Casadei B, Achenbach S, Wright L, Vardas P, Cardiology ESo (2020) European Society of Cardiology: Cardiovascular Disease Statistics 2019. Eur Heart J 41: 12–85
13. Wang Y, Liu G, Druschel CM, Kirby RS (2013) Maternal race/ethnicity and survival experience of children with congenital heart disease. J Pediatr 163: 1437–1442.e1431-1432
14. Wang Y, Liu G, Canfield MA, Mai CT, Gilboa SM, Meyer RE, Anderka M, Copeland GE, Kucik JE, Nembhard WN, Kirby RS, Network NBDP (2015) Racial/ethnic differences in survival of United States children with birth defects: a population-based study. J Pediatr 166: 819–826.e811-812
15. Pace ND, Oster ME, Forestieri NE, Enright D, Knight J, Meyer RE (2018) Sociodemographic Factors and Survival of Infants With Congenital Heart Defects. Pediatrics 142:
16. Lopez KN, Morris SA, Sexson Tejtel SK, Espaillat A, Salemi JL (2020) US Mortality Attributable to Congenital Heart Disease Across the Lifespan From 1999 Through 2017 Exposes Persistent Racial/Ethnic Disparities. Circulation 142: 1132–1147
17. Castellanos DA, Lopez KN, Salemi JL, Shamshirsaz AA, Wang Y, Morris SA (2020) Trends in Preterm Delivery among Singleton Gestations with Critical Congenital Heart Disease. J Pediatr 222: 28–34.e24

18. Nembhard WN, Salemi JL, Ethen MK, Fixler DE, Dimaggio A, Canfield MA (2011) Racial/Ethnic disparities in risk of early childhood mortality among children with congenital heart defects. Pediatrics 127: e1128-1138
19. Zavala R, Metais B, Tuckfield L, DelVecchio M, Aronoff S (2020) Pediatric Syncope: A Systematic Review. Pediatr Emerg Care 36: 442–445
20. Saleeb SF, Li WY, Warren SZ, Lock JE (2011) Effectiveness of screening for life-threatening chest pain in children. Pediatrics 128: e1062-1068
21. Newburger JW, Rosenthal A, Williams RG, Fellows K, Miettinen OS (1983) Noninvasive tests in the initial evaluation of heart murmurs in children. N Engl J Med 308: 61–64
22. Anderson JB, Czosek RJ, Knilans TK, Marino BS (2012) The effect of paediatric syncope on health-related quality of life. Cardiol Young 22: 583–588
23. Brokamp C, Beck AF, Goyal NK, Ryan P, Greenberg JM, Hall ES (2019) Material community deprivation and hospital utilization during the first year of life: an urban population-based cohort study. Ann Epidemiol 30: 37–43
24. Krieger N, Waterman P, Chen JT, Soobader MJ, Subramanian SV, Carson R (2002) Zip code caveat: bias due to spatiotemporal mismatches between zip codes and US census-defined geographic areas–the Public Health Disparities Geocoding Project. Am J Public Health 92: 1100–1102
25. Rossiter K. Census Blogs [Internet]. Katy Rossiter. 2014 Jul - [cited 2021 Sept 28] Available from: https://www.census.gov/newsroom/blogs/random-samplings/2014/07/understanding-geographic-relationships-counties-places-tracts-and-more.html
26. Harrell, FE. rms: Regression Modeling Strategies. R package version 6.0–0. 2020. Accessed November 20, 2020. https://CRAN.R-project.org/package=rms
27. Team, RC. R: A language and environment for statistical computing. 2020. Accessed November 20, 2020. https://www.r-project.org/
28. Census Reporter [Internet]. Illinois; 2019 [cited 2021 October 24]. Available from https://censusreporter.org/profiles/31000US17140-cincinnati-oh-ky-in-metro-area/. Accessed October 10, 2021.
29. Forrest CB, Shadmi E, Nutting PA, Starfield B (2007) Specialty referral completion among primary care patients: results from the ASPN Referral Study. Ann Fam Med 5: 361–367
30. Gamble VN (1997) Under the shadow of Tuskegee: African Americans and health care. Am J Public Health 87: 1773–1778
31. Bailey ZD, Krieger N, Agénor M, Graves J, Linos N, Bassett MT (2017) Structural racism and health inequities in the USA: evidence and interventions. Lancet 389: 1453–1463
32. Arnett MJ, Thorpe RJ, Gaskin DJ, Bowie JV, LaVeist TA (2016) Race, Medical Mistrust, and Segregation in Primary Care as Usual Source of Care: Findings from the Exploring Health Disparities in Integrated Communities Study. J Urban Health 93: 456–467

33. Diamond L, Izquierdo K, Canfield D, Matsoukas K, Gany F (2019) A Systematic Review of the Impact of Patient-Physician Non-English Language Concordance on Quality of Care and Outcomes. J Gen Intern Med 34: 1591–1606
34. Hsueh L, Hirsh AT, Maupomé G, Stewart JC (2021) Patient-Provider Language Concordance and Health Outcomes: A Systematic Review, Evidence Map, and Research Agenda. Med Care Res Rev 78: 3–23
35. Parker MM, Fernández A, Moffet HH, Grant RW, Torreblanca A, Karter AJ (2017) Association of Patient-Physician Language Concordance and Glycemic Control for Limited-English Proficiency Latinos With Type 2 Diabetes. JAMA Intern Med 177: 380–387
36. Traylor AH, Schmittdiel JA, Uratsu CS, Mangione CM, Subramanian U (2010) Adherence to cardiovascular disease medications: does patient-provider race/ethnicity and language concordance matter? J Gen Intern Med 25: 1172–1177
37. Zhao C, Dowzicky P, Colbert L, Roberts S, Kelz RR (2019) Race, gender, and language concordance in the care of surgical patients: A systematic review. Surgery 166: 785–792
38. Johnson-Agbakwu CE, Ali NS, Oxford CM, Wingo S, Manin E, Coonrod DV (2020) Racism, COVID-19, and Health Inequity in the USA: a Call to Action. J Racial Ethn Health Disparities:
39. Evans MK (2020) Health Equity - Are We Finally on the Edge of a New Frontier? N Engl J Med 383: 997–999
40. Satou GM, Rheuban K, Alverson D, Lewin M, Mahnke C, Marcin J, Martin GR, Mazur LS, Sahn DJ, Shah S, Tuckson R, Webb CL, Sable CA, Research AHACCDCotCoCDitYaCoQCaO (2017) Telemedicine in Pediatric Cardiology: A Scientific Statement From the American Heart Association. Circulation 135: e648-e678
41. Chowdhury D, Hope KD, Arthur LC, Weinberger SM, Ronai C, Johnson JN, Snyder CS (2020) Telehealth for Pediatric Cardiology Practitioners in the Time of COVID-19. Pediatr Cardiol 41: 1081–1091
42. Belmont JM, Mattioli LF (2003) Accuracy of analog telephonic stethoscopy for pediatric telecardiology. Pediatrics 112: 780–786
43. Dahl LB, Hasvold P, Arild E, Hasvold T (2002) Heart murmurs recorded by a sensor based electronic stethoscope and e-mailed for remote assessment. Arch Dis Child 87: 297–301; discussion 297–301
44. Mahnke CB, Mulreany MP, Inafuku J, Abbas M, Feingold B, Paolillo JA (2008) Utility of store-and-forward pediatric telecardiology evaluation in distinguishing normal from pathologic pediatric heart sounds. Clin Pediatr (Phila) 47: 919–925
45. Kevat A, Manohar J, Bate N, Harris K (2019) Online referral and immediate appointment selection system empowers families and improves access to public community paediatric clinics. J Paediatr Child Health 55: 454–458
46. Ray KN, Mehrotra A, Yabes JG, Kahn JM (2020) Telemedicine and Outpatient Subspecialty Visits Among Pediatric Medicaid Beneficiaries. Acad Pediatr 20: 642–651

Tables

Table 1
Demographics of Referred Patients

Variable	
Total Referrals	10610
Gender	
Female	5144 (48%)
Male	5466 (52%)
Race/Ethnicity	
White	8015 (76%)
Black	1977 (19%)
Hispanic/Latino	339 (3.2%)
Asian	279 (2.6%)
Language	
English	10244 (97%)
Spanish	226 (2.1%)
Other	140 (1.3%)
Insurance type	
Medicaid	4912 (46%)
Private	5698 (54%)
Age at referral, median (IQR)	9.0 (2.0, 14.0)
Age at referral by year	
< 1	1549 (15%)
1–6	2730 (26%)
7–12	2574 (24%)
> 12	3757 (35%)
Referral Reason	
Abnormal echocardiogram/fetal imaging	168 (1.6%)
Abnormal EKG	382 (3.6%)
Cardiomyopathy	142 (1.3%)

Variable	
Chest Pain	1045 (9.8%)
Congenital Heart Disease	401 (3.8%)
Cyanosis	90 (0.8%)
Dizziness/Syncope	957 (9.0%)
Exercise Intolerance/Dyspnea	128 (1.2%)
Family History	383 (3.6%)
Genetic diagnosis	308 (2.9%)
Murmur	3451 (33%)
Palpitations	445 (4.2%)
Preventative Cardiology	1613 (15%)
Other	1097 (10%)
Referral Season	
December-February	2281 (21%)
March-May	2454 (23%)
June-August	3081 (29%)
September-November	2794 (26%)

Table 2
Variables Associated with Unscheduled Appointment (n = 10,610)

Variable	Appointment Scheduled [a]	Appointment Unscheduled	p-value [b]	OR (95% CI) [c]
Total Referrals	8767 (83%)	1843 (17%)		
Gender			0.900	
Female	4247 (48%)	897 (49%)		1.04 (0.93; 1.15)
Male	4520 (52%)	946 (51%)		reference
Race/Ethnicity			< 0.001	
White	6744 (77%)	1271 (69%)		reference
Black	1488 (17%)	489 (27%)		1.66 (1.44; 1.90)
Hispanic/Latino	299 (3.4%)	40 (2.2%)		0.63 (0.40; 0.98)
Asian	236 (2.7%)	43 (2.3%)		1.04 (0.74; 1.48)
Language			0.064	
English	8448 (96%)	1796 (97%)		reference
Spanish	196 (2.2%)	30 (1.6%)		1.06 (0.63; 1.78)
Other	123 (1.4%)	17 (0.9%)		0.66 (0.39; 1.13)
Median Age at Referral (IQR)	9.0 (2.0, 14.0)	12.0 (6.0, 15.0)	< 0.001	1.42 (1.21; 1.68) [d]
Median Deprivation Index (IQR)	0.35 (0.27, 0.44)	0.35 (0.27, 0.45)	0.084	1.22 (1.00; 1.48) [e]
Insurance type			< 0.001	
Medicaid	3954 (45%)	958 (52%)		1.37 (1.21; 1.54)
Private	4813 (55%)	885 (48%)		reference
Referral Reason			< 0.001	

Variable	Appointment Scheduled [a]	Appointment Unscheduled	p-value [b]	OR (95% CI) [c]
Abnormal echocardiogram/fetal imaging	152 (1.7%)	16 (0.9%)		1.06 (0.62; 1.81)
Abnormal EKG	334 (3.8%)	48 (2.6%)		0.96 (0.69; 1.34)
Cardiomyopathy	95 (1.1%)	47 (2.6%)		3.87 (2.65; 5.65)
Chest Pain	877 (10%)	168 (9.1%)		1.26 (1.02; 1.58)
Congenital Heart Disease	339 (3.9%)	62 (3.4%)		1.69 (1.26; 2.27)
Cyanosis	77 (0.9%)	13 (0.7%)		1.70 (0.93; 3.12)
Dizziness/Syncope	778 (8.9%)	179 (9.7%)		1.55 (1.24; 1.94)
Exercise Intolerance/Dyspnea	105 (1.2%)	23 (1.2%)		1.59 (0.98; 2.55)
Family History	280 (3.2%)	103 (5.6%)		2.56 (1.97; 3.33)
Genetic Diagnosis	242 (2.8%)	66 (3.6%)		2.09 (1.55; 2.83)
Murmur	3092 (35%)	359 (19%)		reference
Palpitations	382 (4.4%)	63 (3.4%)		1.12 (0.82; 1.51)
Preventative Cardiology	1116 (13%)	497 (27%)		2.91 (2.43; 3.47)
Other	898 (10%)	199 (11%)		1.70 (1.39; 2.07)
Referral Season			0.400	
Dec-Feb	1871 (21%)	410 (22%)		1.11 (0.96; 1.29)
Mar-May	2007 (23%)	447 (24%)		1.14 (0.99; 1.32)
Jun-Aug	2563 (29%)	518 (28%)		reference

Variable	Appointment Scheduled [a]	Appointment Unscheduled	p-value [b]	OR (95% CI) [c]
Sep-Nov	2326 (27%)	468 (25%)		1.03 (0.89; 1.18)

a. Values presented as n (%) unless otherwise specified.

b. P-values calculated using chi-square test or Wilcoxon rank-sum test.

c. OR: odds ratio from logistic regression model for unscheduled appointment; model adjusted for the variables listed in Table 2; CI: confidence interval.

d. OR for age at referral calculated comparing age at 75th versus 25th percentile.

e. OR for deprivation index calculated comparing deprivation index of 0.66 (top 5th% most deprived) to 0.38 (national median).

Table 3
Variables Associated with Incomplete Visit (n = 8,767)

Variable	Visit Complete [a]	Visit Incomplete	p-value [b]	OR (95% CI) [c]
Total Referrals	6954 (79%)	1813 (21%)		
Gender			0.800	
Female	3375 (49%)	872 (48%)		1.00 (0.90; 1.11)
Male	3579 (51%)	941 (52%)		reference
Race/Ethnicity			< 0.001	
White	5450 (78%)	1294 (71%)		reference
Black	1065 (15%)	423 (23%)		1.41 (1.22; 1.63)
Hispanic/Latino	239 (3.4%)	60 (3.3%)		1.10 (0.75; 1.63)
Asian	200 (2.9%)	36 (2.0%)		0.73 (0.50; 1.07)
Language			0.700	
English	6697 (96%)	1751 (97%)		reference
Spanish	160 (2.3%)	36 (2.0%)		0.68 (0.41; 1.11)
Other	97 (1.4%)	26 (1.4%)		1.07 (0.67; 1.69)
Median Age at Referral (IQR)	9.0 (2.0, 14.0)	9.0 (2.0, 14.0)	0.200	1.02 (0.86; 1.20) [d]
Median Deprivation Index (IQR)	0.34 (0.26, 0.43)	0.37 (0.28, 0.46)	< 0.001	1.32 (1.08; 1.61) [e]
Insurance Type			< 0.001	
Medicaid	2991 (43%)	963 (53%)		1.29 (1.14; 1.46)
Private	3963 (57%)	850 (47%)		reference
Referral Reason			< 0.001	

Variable	Visit Complete [a]	Visit Incomplete	p-value [b]	OR (95% CI) [c]
Abnormal echocardiogram/fetal imaging	114 (1.6%)	38 (2.1%)		1.62 (1.09; 2.38)
Abnormal EKG	280 (4.0%)	54 (3.0%)		1 .00 (0.72; 1.38)
Cardiomyopathy	71 (1.0%)	24 (1.3%)		1.33 (0.82; 2.18)
Chest Pain	782 (9.9%)	208 (9.6%)		1.25 (1.01; 1.56)
Congenital Heart Disease	250 (3.6%)	89 (4.9%)		1.60 (1.22; 2.08)
Cyanosis	64 (0.9%)	13 (0.7%)		1.11 (0.60; 2.05)
Dizziness/Syncope	644 (9.3%)	134 (7.4%)		1.09 (0.86; 1.37)
Exercise Intolerance/Dyspnea	84 (1.2%)	21 (1.2%)		1.59 (0.98; 2.55)
Family History	218 (3.1%)	62 (3.4%)		1.15 (0.84; 1.57)
Genetic Diagnosis	164 (2.4%)	78 (4.3%)		1.93 (1.44; 2.60)
Murmur	2544 (37%)	548 (30%)		reference
Palpitations	309 (4.4%)	73 (4.0%)		1.21 (0.91; 1.62)
Preventative Cardiology	820 (12%)	296 (16%)		1.42 (1.17; 1.73)
Other	688 (9.9%)	210 (12%)		1.40 (1.16; 1.70)
Referral Season			0.110	
Dec-Feb	1448 (21%)	423 (23%)		1.20 (1.03; 1.39)
Jun-Aug	2042 (29%)	521 (29%)		reference
Mar-May	1614 (23%)	393 (22%)		1.00 (0.86; 1.16)
Sep-Nov	1850 (27%)	476 (26%)		1.02 (0.89; 1.18)

Variable	Visit Complete [a]	Visit Incomplete	p-value [b]	OR (95% CI) [c]
Days from Referral to Appointment Scheduled			< 0.001	
< 7	1508 (22%)	231 (13%)		0.62 (0.52; 0.74)
7–14	1344 (19%)	278 (15%)		0.85 (0.72; 1.01)
15–30	2005 (29%)	493 (27%)		reference
31–60	1286 (18%)	442 (24%)		1.39 (1.20; 1.61)
61–90	386 (5.6%)	166 (9.2%)		1.66 (1.33; 2.06)
> 90	425 (6.1%)	203 (11%)		1.82 (1.48; 2.23)

a. Values presented as n (%) unless otherwise specified.

b. P-values calculated using chi-square test or Wilcoxon rank-sum test.

c. OR: odds ratio from logistic regression model for incomplete visits; model adjusted for the variables listed in Table 3; CI: confidence interval.

d. OR for age at referral calculated comparing age at 75th versus 25th percentile.

e. OR for deprivation index calculated comparing deprivation index of 0.66 (top 5th% most deprived) to 0.38 (national median).

Figures

Reason for Referral

- Abnormal echocardiogram or fetal imaging
- Abnormal EKG
- Cardiomyopathy (includes those with family history of cardiomyopathy)
- Chest pain
- Congenital heart disease
- Cyanosis
- Dizziness/syncope
- Exercise intolerance/Dyspnea
- Family history (includes any patient with concerning family cardiac history including sudden cardiac death, arrythmias, ischemic heart disease, and structural abnormalities)
- Genetic diagnosis (includes patients with known or suspected genetic diagnosis that has increased risk of cardiovascular structural abnormalities or disease)
- Palpitations
- Preventative cardiology (includes referrals for elevated blood pressures, elevated lipids, and obesity or other metabolic conditions that increase risk of heart disease)
- Other

* If there were multiple referral reasons the first referral reason was used to categorize the referral.

Figure 1

List of the reason for referral by category.

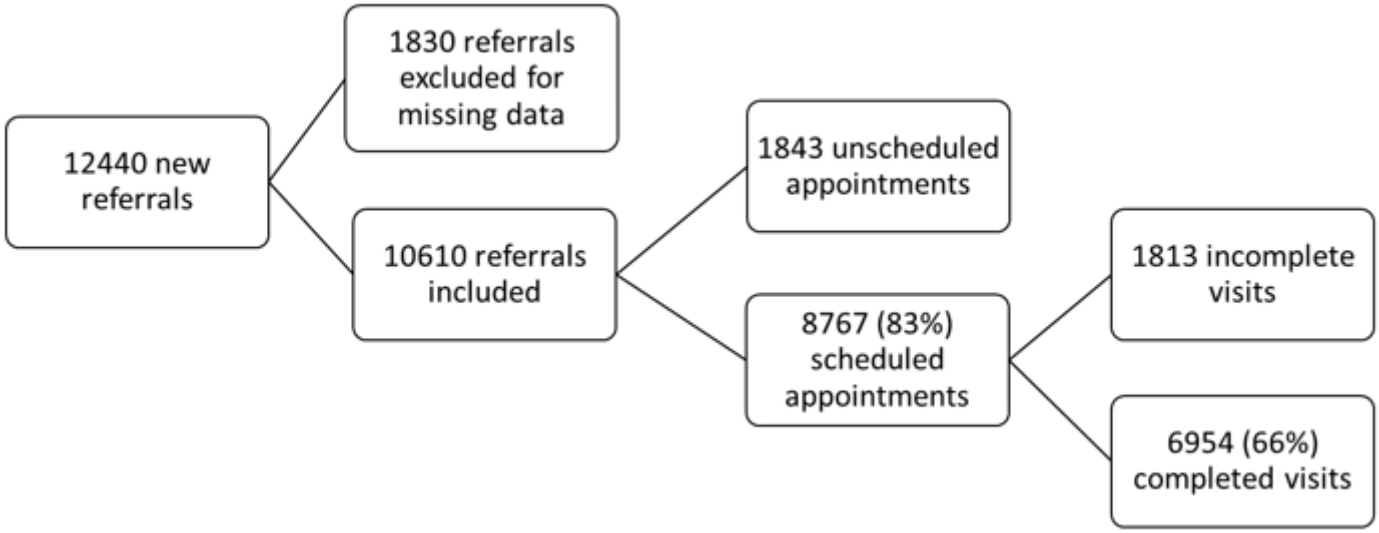

Figure 2

Study Flow Diagram for referrals placed from 2017 to 2019. Completed visit percentage is based off the total number of referrals, including both those who scheduled visits and did not scheduled visits

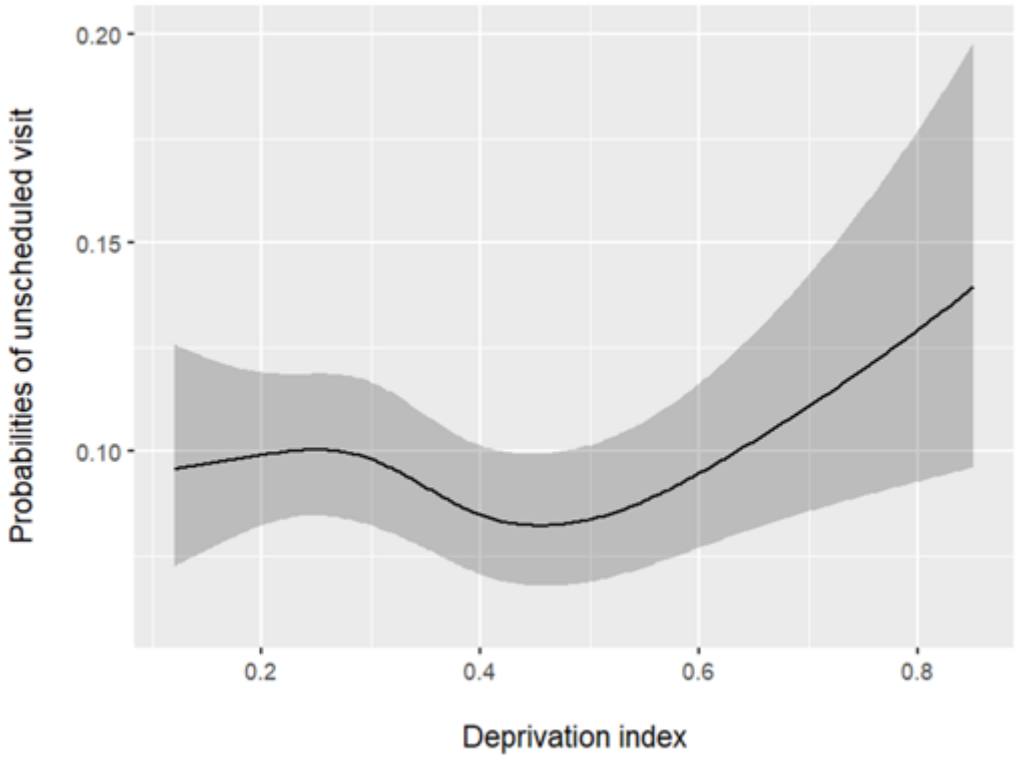

Figure 3

The probability of unscheduled visit (calculated from logistic regression model) is on the y axis and DI is on the x axis. The area shaded grey represents the 95% confidence interval. It demonstrates that up to and slightly after the national mean (0.38) there is no clear association, but at higher rates of deprivation there is a higher likelihood of unscheduled visit

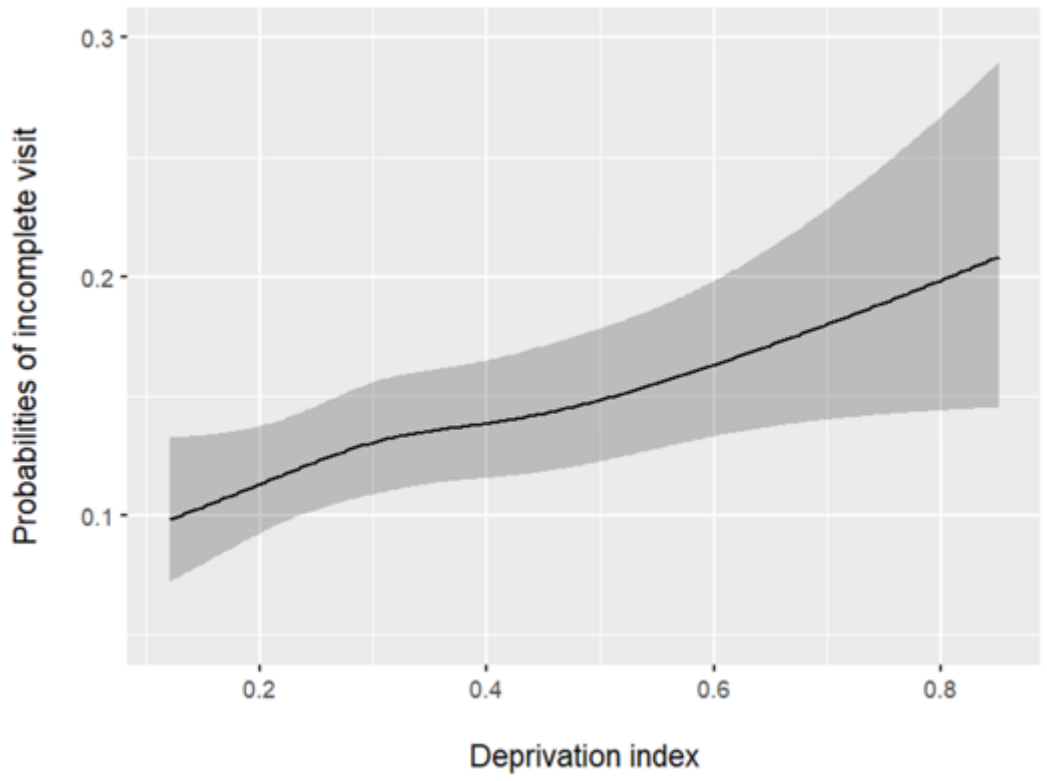

Figure 4

The probability of incomplete referral (calculated from logistic regression model) is on the y axis and DI is on the x axis. The area shaded grey represents the 95% confidence interval. At increasing levels of deprivation there are higher rates of incomplete visit

Supplementary Files

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- OnlineResource1.docx