

# **Demographic and Socioeconomic Disparities in Telemedicine Utilisation Among Individuals with Type 2 Diabetes in Primary Care: A Systematic Review and Meta-Analysis**

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# Demographic and Socioeconomic Disparities in Telemedicine Utilisation Among Individuals with Type 2 Diabetes in Primary Care: A Systematic Review and Meta-Analysis

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## Abstract

**Background:** Importance: Telemedicine has revolutionized the management of type 2 diabetes mellitus (T2DM) in primary care by improving access to healthcare services and enhancing health outcomes. Despite these advancements, it remains unclear whether telemedicine has reduced access inequalities among different demographic and socioeconomic groups.

**Objective:** To investigate the most important demographic and socioeconomic factors associated with telemedicine use among individuals with T2DM in primary care.

**Methods:** We included observational and cohort studies that assessed the effects of telemedicine interventions on individuals with T2DM in primary care. The core outcome were the factors associated with telemedicine use, reported as adjusted odds ratios (AORs) with their 95% confidence intervals for each factor, using a random-effects model. Heterogeneity was quantified using the  $I^2$  statistic, and publication bias was assessed. The protocol for this review was registered at PROSPERO (ID: CRD42024550410).

**Results:** Of the 3000 records identified, 16 studies involving 71 336 patients were included in the meta-analysis. Female patients had higher odds of using telemedicine than male patients (pooled OR: 1.053; 95% CI: 1.02 to 1.09). Older adults were significantly less likely to use telemedicine than younger adults (pooled OR: 0.979; 95% CI: 0.98 to 0.98). Compared to White patients, Black patients were less likely to use telemedicine (pooled OR: 0.55; 95% CI: 0.32 to 0.94), while no statistically significant differences were observed for Hispanic (pooled OR: 1.075; 95% CI: 0.36 to 3.24) or Asian participants (pooled OR: 0.56; 95% CI: 0.29 to 1.06). Patients with higher education levels had greater odds of using telemedicine than those with lower education levels (pooled OR: 1.681; 95% CI: 1.48 to 1.91).

**Conclusions:** Conclusion: This systematic review and meta-analysis provide evidence of significant disparities in telemedicine utilisation among men, older adults, black individuals and those with lower levels of education who have T2DM in primary care. Given that these groups are among the most vulnerable to T2DM, these disparities highlight the critical need for strategic interventions and robust policy that ensure telemedicine fosters equitable access to healthcare, while preventing further exacerbation of existing health inequalities.

**Conclusion:** This systematic review and meta-analysis provide evidence of significant disparities in telemedicine utilisation among men, older adults, black individuals and those with lower levels of education who have T2DM in primary care. Given that these groups are among the most vulnerable to T2DM, these disparities highlight the critical need for strategic interventions and robust policy that ensure telemedicine fosters equitable access to healthcare, while preventing further exacerbation of existing health inequalities.

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## **Demographic and Socioeconomic Disparities in Telemedicine Utilisation Among Individuals with Type 2 Diabetes in Primary Care: A Systematic Review and Meta-Analysis**

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**Abstract:**

**Importance:** Telemedicine has revolutionized the management of type 2 diabetes mellitus (T2DM) in primary care by improving access to healthcare services and enhancing health outcomes. Despite these advancements, it remains unclear whether telemedicine has reduced access inequalities among different demographic and socioeconomic groups.

**Objective:** To investigate the most important demographic and socioeconomic factors associated with telemedicine use among individuals with T2DM in primary care.

**Design:** Systematic review and meta-analysis.

**Data sources:** MEDLINE, EMBASE, PsycINFO, Google Scholar, SCOPUS, and CINAHL from inception to December 2023. The reference lists of eligible studies and other relevant systematic reviews were also searched.

**Methods:** We included observational and cohort studies that assessed the effects of telemedicine interventions on individuals with T2DM in primary care. The core outcome were the factors associated with telemedicine use, reported as adjusted odds ratios (AORs) with their 95% confidence intervals for each factor, using a random-effects model. Heterogeneity was quantified using the  $I^2$  statistic, and publication bias was assessed. The protocol for this review was registered at PROSPERO (ID: CRD42024550410).

**Results:** Of the 3000 records identified, 16 studies involving 71 336 patients were included in the meta-analysis. Female patients had higher odds of using telemedicine than male patients (pooled OR: 1.053; 95% CI: 1.02 to 1.09). Older adults were significantly less likely to use telemedicine than younger adults (pooled OR: 0.979; 95% CI: 0.98 to 0.98). Compared to White patients, Black patients were less likely to use telemedicine (pooled OR: 0.55; 95% CI: 0.32 to 0.94), while no statistically significant differences were observed for Hispanic (pooled OR: 1.075; 95% CI: 0.36 to 3.24) or Asian participants (pooled OR: 0.56; 95% CI: 0.29 to 1.06). Patients with higher education levels had greater odds of using telemedicine than those with lower education levels (pooled OR: 1.681; 95% CI: 1.48 to 1.91).

**Conclusion:** This systematic review and meta-analysis provide evidence of significant disparities in telemedicine utilisation among men, older adults, black individuals and those with lower levels of education who have T2DM in primary care. Given that these groups are among the most vulnerable to T2DM, these disparities highlight the critical need for strategic interventions and robust policy that ensure telemedicine fosters equitable access to healthcare, while preventing further exacerbation of existing health inequalities.

## 1. Introduction

Every 10 seconds, a person dies from diabetes-related complications worldwide. [1] In 2022, the global prevalence of diabetes reached an alarming 828 million, a dramatic increase from 198 million in 1990. [2] Type 2 diabetes mellitus (T2DM) is a significant contributor to this rise, with an estimated 462 million people affected, making up 6.28% of the world's population. [3] This escalating trend disproportionately impacts already vulnerable populations, particularly racial and ethnic minorities, who face compounded challenges in accessing essential healthcare services. [4] [5] In the UK, the prevalence of T2DM among Asian and Black ethnic groups is two to four times higher than that of White and other ethnic groups. [6] This troubling increase highlights the urgent need to improve healthcare services for underserved populations with T2DM.

In response to the growing diabetes prevalence and the increasing demand for accessible healthcare services, telemedicine has become an important component of the healthcare system. [7] [8] Telemedicine refers to the delivery of healthcare services over distances using advanced technologies. It integrates a variety of technologies, such as virtual consultations, wearable devices, and mobile health apps, allowing healthcare providers to deliver equitable, affordable, and high-quality care remotely for individuals with T2DM. [9] Numerous studies emphasize the effectiveness of telemedicine, showing that it is not only as effective as traditional care but in some cases, even more effective in improving health outcomes, optimizing diabetes management, and enhancing patient engagement. [10], [11] Despite the transformative promise of telemedicine in revolutionizing diabetes care, substantial challenges continue to impede its effective management of T2DM, particularly among underserved communities. [4] [12]. Preliminary evidence highlights persistent disparities, with racial and ethnic minorities, especially Black individuals, being significantly less likely to utilise telemedicine compared to their White counterparts. [13] Moreover, uninsured individuals or those with limited health coverage demonstrate markedly lower telemedicine adoption rates compared to those with private or public insurance. [14] These disparities are exacerbated by multifaceted barriers, including inadequate digital literacy, poor health literacy, restricted access to digital devices, and language proficiency limitations, which collectively hinder equitable telemedicine adoption in vulnerable populations. [15], [16]

Understanding the distinct characteristics of individuals with T2DM is essential for designing interventions that address disparities in telemedicine access and improve healthcare delivery for diabetic patients. A key challenge is understanding how various demographic and socioeconomic factors influence the adoption and utilisation of telemedicine among individuals with T2DM in primary care. This study aims to bridge these gaps by conducting a comprehensive systematic review and meta-analysis of existing literature, exploring the relationships between demographic and socioeconomic factors and their impact on telemedicine adoption and utilisation for T2DM care.

## 2. Methods/design:

### 2.1 Overview

A systematic review was conducted and reported in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. [17] The protocol for this review was registered at PROSPERO (ID: CRD42024550410).

### 2.2 Selection criteria

The eligibility criteria for study inclusion were developed using the PICOS framework (see

table 1).

### **2.3 Information sources**

MEDLINE, EMBASE, PsycINFO, Google Scholar, SCOPUS, and CINAHL were searched from inception through December 2023. Additionally, the bibliographies of relevant systematic reviews were reviewed to identify any further publications, and content experts, as well as prolific authors in the field, were contacted.

### **2.4 Search strategy**

A search strategy using medical subject heading (MeSH) terms were designed to target four key domains: telehealth/telemedicine, primary care, adoption and utilisation. Pilot searches were undertaken for each domain and combined concepts to ensure that the search strategy was effective. The search strategy included a combination of Medical Subject Headings and free-text words. The MEDLINE (Ovid) search strategy that was used to identify papers is presented in Additional file 1. There was no limitation of language and reference lists of all included studies were also screened for additional literature. Furthermore, we contacted the library to obtain full-text articles not found in the search, as well as reached out to experts and authors who are prolific in the field for additional studies

### **2.5 Study selection**

Search results were imported into the EndNote reference management software (version 14), where duplicates were removed automatically and double checked manually. Titles and abstracts of all identified records were independently assessed by NA and MP. The studies meeting all the eligible criteria were retained for independent full-text assessment against the selection criteria, by the first reviewer (NA) and confirmed by two other reviewers (EK and MP). Any discrepancies between reviewers were resolved through discussion.

### **2.6 Data extraction**

Data were extracted using a standardized form developed by (NA) and refined by (EK). The data extraction process was conducted by one reviewer (NA) and checked by a second reviewer (EK). Any disagreement was resolved through discussion or through an assessment by a third reviewer (MP). The inter-rater reliability was excellent ( $\kappa = 0.896$ ).

### **2.7 Risk of bias assessment**

The quality appraisal of the studies for the assessment of the risks of bias was carried out using the ROBINS-I tool (Risk of Bias In Non-randomized Studies - of Interventions), which is recommended by the Cochrane Scientific Committee for non-randomized studies of interventions.[18] The ROBINS-I assesses the risk of bias in seven domains, which include missing data, classification of interventions, selection of participants, deviations from intended interventions, missing data, measurement of the outcome, and selection of the reported result. The first reviewer (NA) completed the risk of bias assessment on all selected studies which was confirmed by four other reviewers (EK, MP, LH and SZ).

### **2.8 Data synthesis**

A meta-analysis was performed using random-effects models on the extracted data from the selected studies. A pooled adjusted odds ratio (AOR) for all outcomes was calculated. The study outcomes were pooled using a non-parametric bootstrap of the DerSimonian-Laird random-effects method (1000 iterations) [19] implemented in the Stata package *mean*. [20] A random-effects model was preferred because it is a more conservative approach compared to a fixed-effect model [21] especially when heterogeneity is expected.

The assumption of homogeneity of true effect sizes was assessed using Cochran's Q test, and the degree of inconsistency across studies ( $I^2$ ) was calculated. [22] describes the percentage of total variation across studies that is due to heterogeneity rather than sampling error and ranges from 0% (no inconsistency) to 100% (high heterogeneity), with values of 0%-40% suggesting low heterogeneity, 30%-60% moderate heterogeneity, 50%-90% substantial heterogeneity, and 75%-100% considerable heterogeneity.[23]

For each meta-analysis with 10 or more studies, funnel plots, the Begg test, and the Egger test were used to examine publication bias [24]. The trim-and-fill method was employed as a sensitivity analysis to observe possible small study publication bias.

### 3. Results

The research initially yielded 3000 citations, after removing duplicates and reviewing the titles and abstracts, 2261 studies were excluded. Of the remaining 609 studies, 592 were excluded after reviewing the full texts (Figure 1). A total of 17 studies were included in the review. [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40]

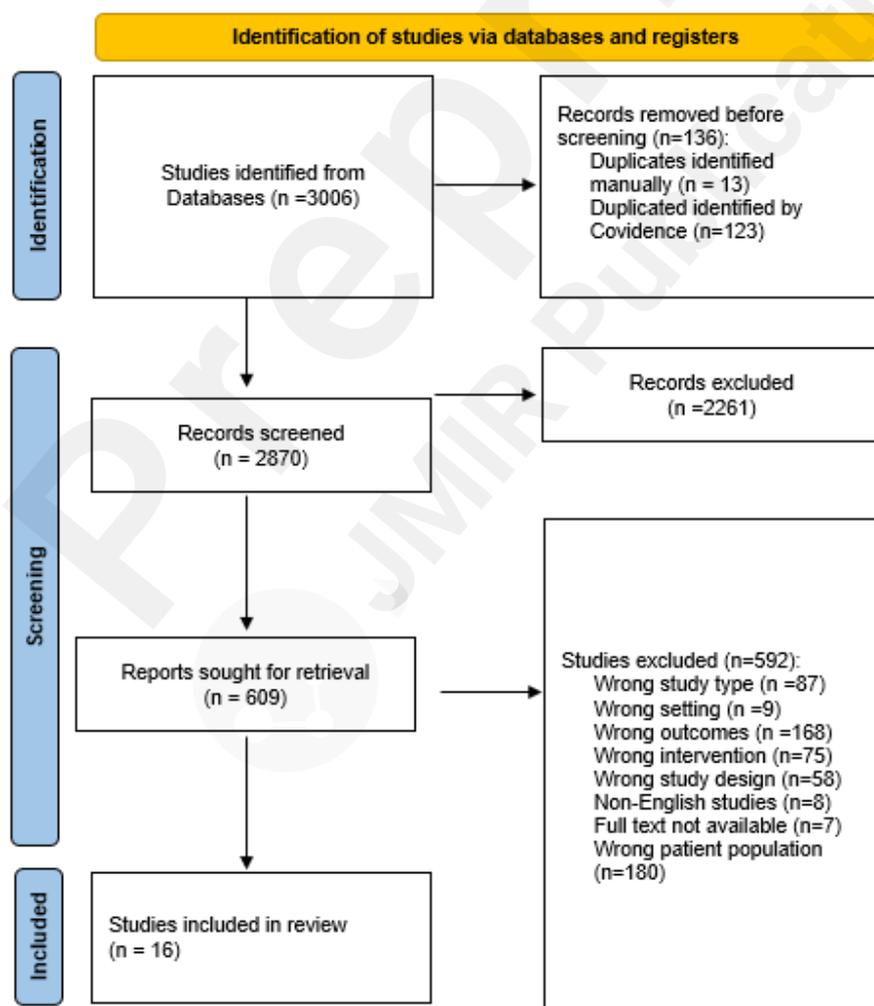


Figure 1 shows Flowchart of the inclusion of studies in the review.

### 3.1 Characteristics of included studies:

This review includes a pooled sample of 71,336 patients, with sample sizes ranging from 115 to 38,399 (median= 1133). Most studies were conducted in the US (10 studies, 62%), followed by the Netherlands (4 studies, 25%) and the UK (2 studies, 13%). Most studies had a cross-sectional design (10 studies, 63%), while six studies (38%) used a cohort design. Most studies focused on patients with T2DM (6 studies, 38%), five studies (31%) included populations where more than 50% had T2DM, and five studies (31%) did not specify the type of diabetes. Most studies were conducted in primary care settings (14 studies, 88%), with two studies conducted in both primary and secondary care settings. Among the studies reviewed, 13 used asynchronous interventions (web-based portals, secure messaging, text messages, store-and-forward images), two used synchronous interventions (real-time video consultations, telephone-based counselling), and one combined both types of interventions. The characteristics of all studies included in this review are presented in Table 2.

### 3.2 Risk of bias results:

The Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) tool was used to assess the risk of bias in the included studies [12]. Among these, five studies [26], [31], [34], [38], [40] were found to have a low risk of bias, while eight studies [25], [28], [29], [30], [32], [33], [36], [39] exhibited a medium risk of bias. However, a critical risk of bias due to missing data was identified in 3 studies. [27], [35], [37] The risk of bias assessment for all studies in this review can be found in Figure 2.

### 3.3 Demographic characteristics:

#### 3.3.1 Gender/Sex

Gender/sex was evaluated in 10 studies (n= 68 355 patients) [25], [26], [29], [30], [32], [33], [36], [37], [39], [40]. This meta-analysis found that the use of telemedicine intervention was statistically significantly higher among females than males (pooled OR: 1.053 (95% CI: 1.02 to 1.09) (Fig. 3). No publication bias regarding gender/sex and the use of telemedicine intervention was observed in the visual analysis of the funnel plot (Fig. 4). Egger's test also revealed no statistical significance for publication bias (P = 0.24).

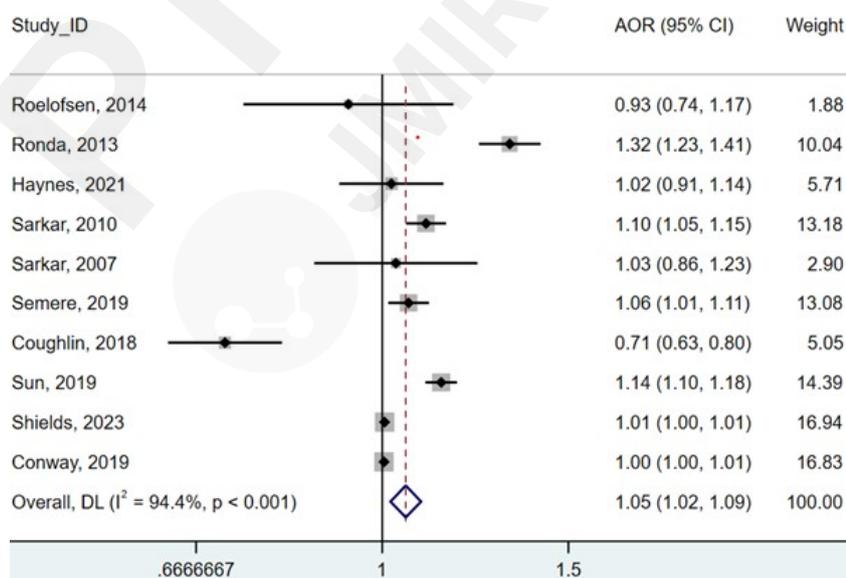


Figure 3

Forest plot of meta-analysis for 10 studies evaluating sex and the use of telemedicine in primary care. Pooled summary effect measures [odds ratio (OR) and 95% confidence interval (CI)] indicated that male sex was significantly associated with the use of telemedicine

interventions. Heterogeneity:  $I^2 = 94.4\%$ .

### 3.3.2 Age

Age was evaluated in 10 studies (n= 47 927 patients) [25], [26], [27], [28], [29], [30], [33], [41], [34], [36], [37] [38], [39], [40], 11 of which were included in the meta-analysis (Fig. 6). It was not possible to pool the data from three studies [33], [37], [39] due to the reporting of age in categorical groups (e.g., age ranges) rather than as means and standard deviations. In this meta-analysis, "older" participants are defined as those whose age is one year above the mean age reported in each study. The results indicate older adults showed lower use of telemedicine than younger adults (pooled OR: 0.98, 95% CI: 0.98 to 0.983). The funnel plot showed little asymmetrical distribution (Fig.7), and Egger's test indicated potential small-study effects for publication bias ( $P < 0.001$ ). However, the trim-and-fill analysis showed no substantial evidence of publication bias (Fig. 8). The observed pooled effect size was 0.95 (95% CI: 0.91 to 0.99), and no studies were imputed, indicating that publication bias is unlikely to meaningfully affect the conclusions of this meta-analysis.

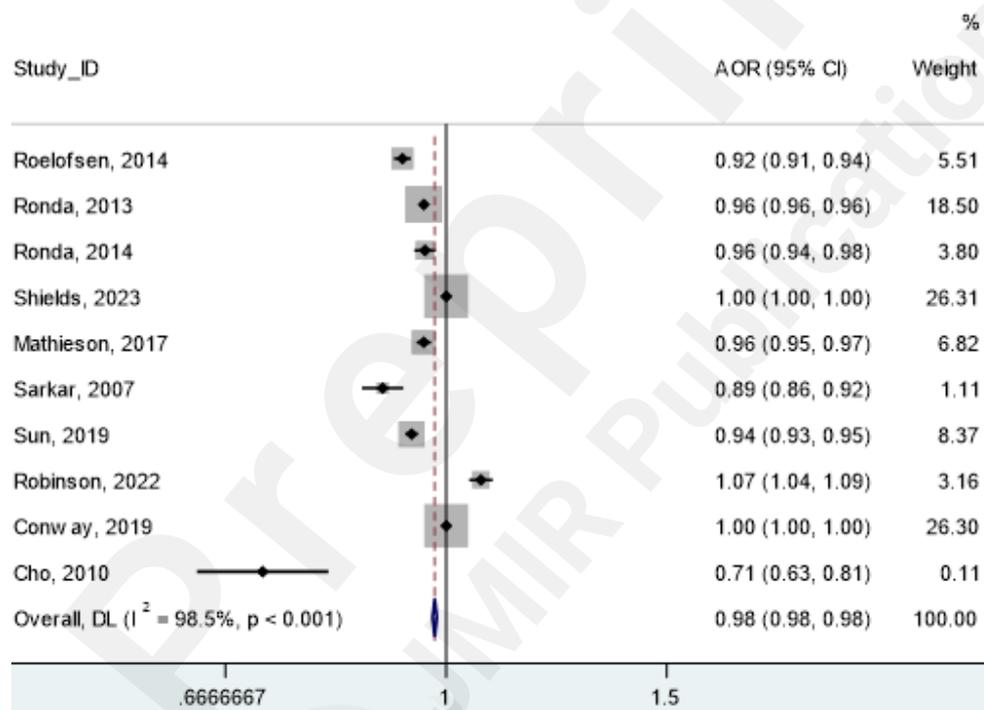


Figure 5

Forest plot of meta-analysis of studies testing association between age and the use of telemedicine in primary care (n = 10). Study-specific and summary effect estimates [odds ratio (OR) and 95% confidence interval (CI)]. Heterogeneity:  $I^2 = 98.5\%$ .

### 3.3.3 Ethnicity/race

A total of nine studies examined racial disparities in the use of telemedicine among individuals with T2DM: five among Black participants [31], [32], [33], [36], [39], three studies among Hispanic participants [32], [36], [39], three among Asian/Pacific Islander participants [31], [32], [33] and eight among other races or unspecified racial groups, [29], [30], [31], [32], [33], [37], [39], [40].

#### 3.3.3.1 Black

Of the five studies that included black participants (n= 13,717 patients), three studies (n= 13 717 patients) observed lower likelihood of using telemedicine among Black participants

compared to White participants [31], [32], [39], although one study was not statistically significant [33], and one study observed that Black participants had 52% higher odds of using telemedicine compared to White participants, however, the confidence interval was wide, indicating that this result could not be considered statistically significant [36]. In this meta-analysis, the overall odds ratio of 0.55 (95% CI: 0.324 to 0.935) shows that Black participants have significantly lower odds of using telemedicine compared to White participants. This result is statistically significant and highlights a disparity in telemedicine use among Black participants (Fig. 9).

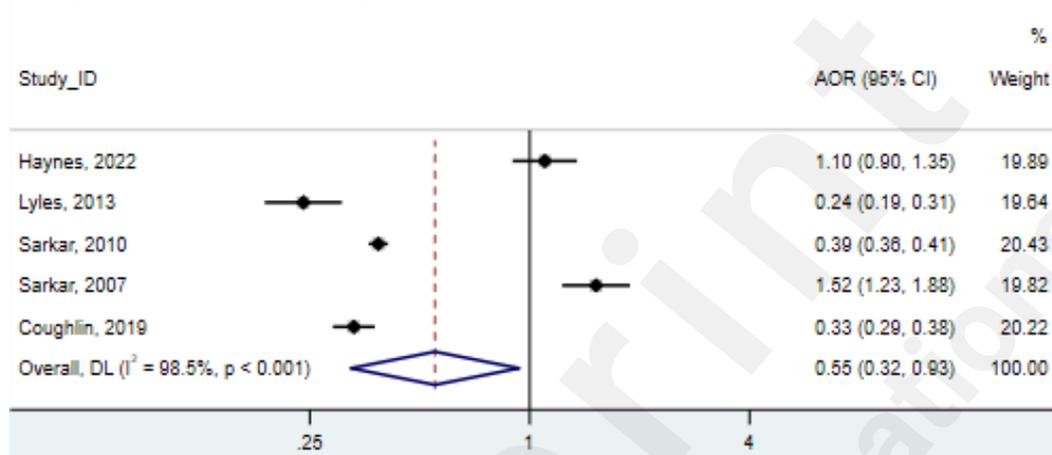


Figure 8

Forest plot of the meta-analysis examining the association between Black participants and the use of telemedicine in primary care ( $n = 5$ ). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity:  $I^2 = 98.5\%$ .

### 3.3.3.2 Hispanic

Of the studies examining Hispanic participants ( $n = 11\,863$  patients) [32], [36], [39], two found that Hispanic participants were less likely to use telemedicine compared to White participants, with both results being statistically significant [32], [39]. In contrast, one study, which included both English-speaking and Spanish-speaking Hispanic participants, found a higher likelihood of telemedicine use among Hispanic participants. [36] These three studies provided highly heterogenous evidence, when comparing Hispanic to White participants, with the meta-analysis result being non-significant with a pooled OR of 1.075 (95% CI: 0.357 to 3.242) (Fig. 10).

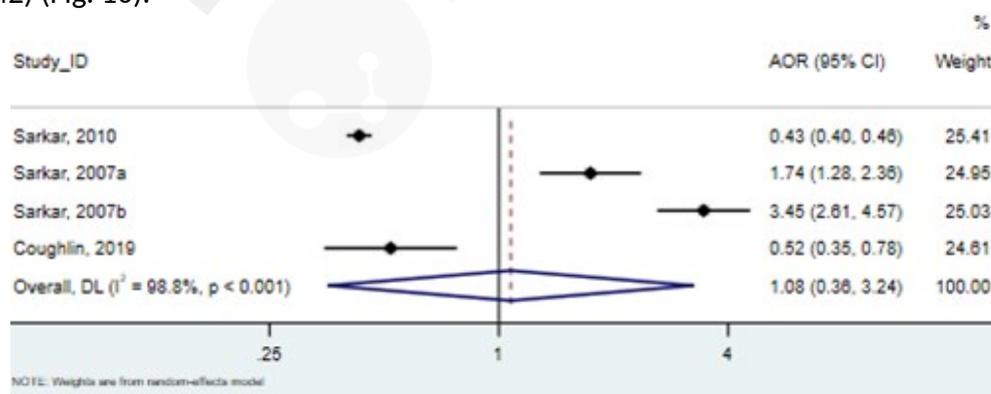


Figure 9

Forest plot of the meta-analysis examining the association between Hispanic participants

and the use of telemedicine in primary care ( $n = 3$ ). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity:  $I^2 = 98.8\%$ . a. English-speaking Hispanic participants. b. Spanish-speaking Hispanic participants.

### 3.3.3.3 Asian

Of the studies examining Asian participants ( $n = 11, 520$  patients) [31], [32], [33], all three studies observed a lower likelihood of using telemedicine compared to White participants. One study reported an odds ratio of 0.87 (95% CI: 0.57 to 1.32), suggesting a 13% lower likelihood of using telemedicine occurring among Asian participants compared to White participants, but this result was not statistically significant. [33] In contrast, another study found a 63% decrease in the likelihood of using telemedicine and this result was statistically significant. The third study examined two groups: Asian and Filipino participants. For Asian participants, the odds ratio was 0.9 (95% CI: 0.77 to 1.05), indicating a 10% lower likelihood of using telemedicine, but this result was not statistically significant. For Filipino participants, the odds ratio was 0.323 (95% CI: 0.278 to 0.385), suggesting a 67.7% lower likelihood of using telemedicine compared to White participants, and this result was statistically significant. In the meta-analysis, the overall odds ratio of 0.56 (95% CI: 0.290 to 1.063) suggests that Asian participants have lower odds of using telemedicine compared to White participants. However, the result is not statistically significant (Fig. 11)

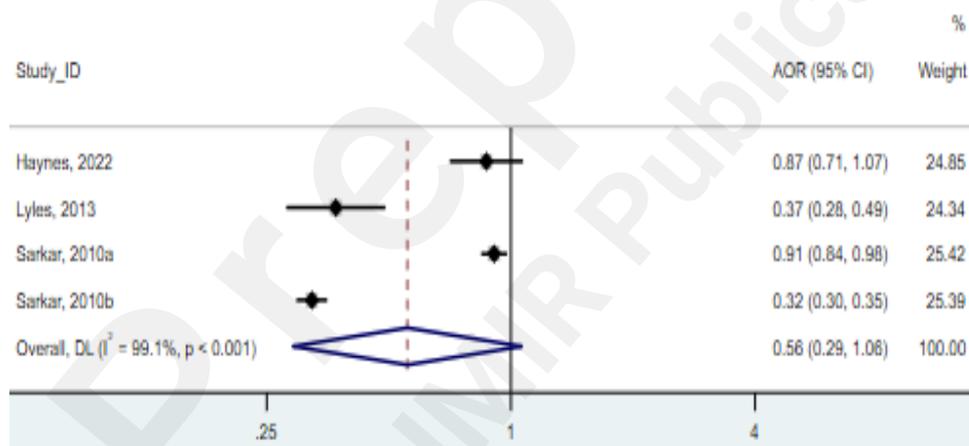


Figure 10

Forest plot of the meta-analysis examining the association between Asian participants and the use of telemedicine in primary care ( $n = 3$ ). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity:  $I^2 = 99.1\%$ . a. Asian participants. b. Filipino.

### 3.3.3.4 Other races or unspecified racial groups

Of the 8 studies ( $n = 66, 923$  patients) that included other races or unspecified racial groups [29], [30], [31], [32], [33], [37], [39], [40], 2 studies observed a statistically significant increase in telemedicine use among these groups compared to White participants [29], [37]. In contrast, 4 studies reported a statistically significant decrease in telemedicine use among these groups compared to White participants [30], [39], [32], [40]. Additionally, two studies reported lower odds of using telemedicine, but the result was not statistically significant [33], [31]. In this meta-analysis, the overall odds ratio of 0.765 (95% CI: 0.677 to 0.865) shows that other races or unspecified racial groups have significantly lower odds of using telemedicine compared to White participants. This result is statistically significant and

highlights a disparity in telemedicine use among these groups (Fig. 12).

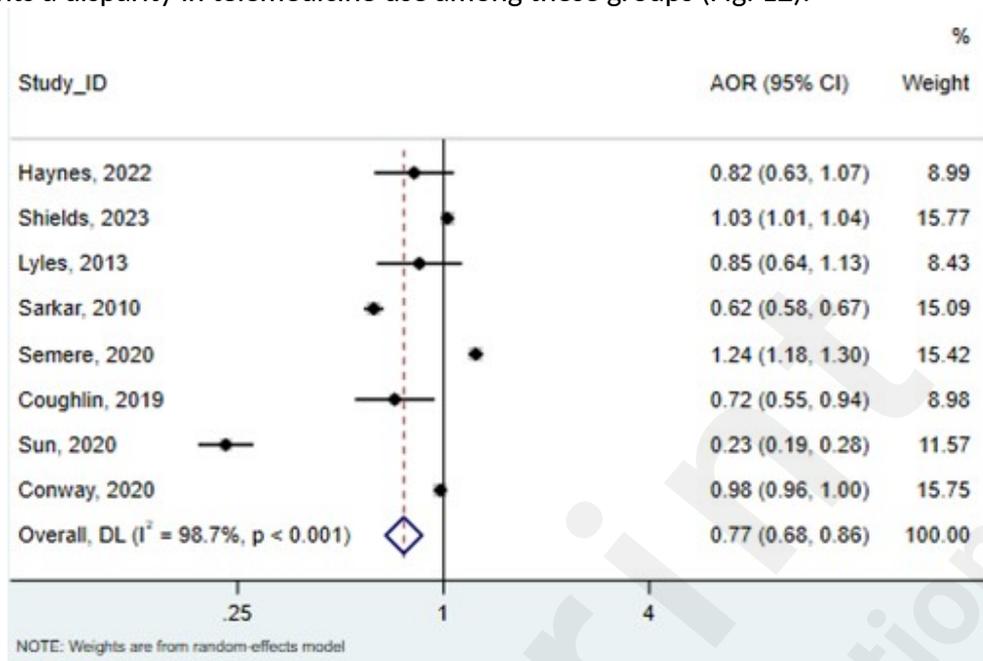


Figure 11

Forest plot of the meta-analysis examining the association between other races or unspecified racial groups and the use of telemedicine in primary care ( $n = 8$ ). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity:  $I^2 = 98.7\%$ .

### 3.4 Socioeconomic factors

#### 3.4.1 Education

Five studies ( $n = 59,609$  patients) were included in this meta-analysis to assess the association between education and the use of telemedicine [26], [28], [40], [32], [37]. The Odds ratios from these studies suggest that individuals with higher education are more likely to use telemedicine than those with lower education, with statistically significant findings in all studies. There was substantial heterogeneity between studies ( $I^2 = 88.5\%$ ;  $p < 0.001$ ), therefore we must be cautious when interpreting the pooled effect estimate. The pooled OR was highest among individuals with higher education compared to those with lower education (pooled OR: 1.681, 95% CI: 1.479 to 1.910). This indicates that individuals with higher education have 68.1% higher odds of using telemedicine compared to those with lower education, as shown in (Fig. 13).

#### 3.4.2 Residence

Two studies ( $n = 39,691$  patients) were included in this meta-analysis to assess the association between urban versus rural settings and the use of telemedicine [33], [40]. The overall effect estimates for the use of telemedicine comparing urban versus rural populations suggested that there is a significant difference between rural and urban samples (OR = 1.005 (95% CI: 1.001 to 1.008), indicating that urban patients are significantly more likely to use telemedicine than rural patients (Fig. 14). There was no observed heterogeneity among the included studies ( $I^2 = 0\%$ ).

### 3.5 Insurance status

The meta-analysis of two studies ( $n = 39,691$  patients) assessed the association between insurance type (public versus private) and the use of telemedicine. Both studies found that individuals with public insurance were significantly less likely to use telemedicine compared

to those with private insurance[33], [40]. The pooled effect estimate was 0.712 (95% CI: 0.592 to 0.856), indicating that individuals with public insurance were 28.8% less likely to use telemedicine compared to those with private insurance (Fig. 15).

#### 4. Discussion

To our knowledge, this is the first meta-analysis that examines the association between demographic, socioeconomic factors, and insurance status with the use of telemedicine among individuals with T2DM in primary care, we quantified the effects from 16 published studies, comprising a total of 71,336 participants. Our analysis revealed a significant association between gender and telemedicine usage, with females showing higher engagement. Interestingly, despite the rapid development and deployment of telemedicine, older adults reported lower usage rates compared to younger adults. Additionally, we found a statistically significant reduction in telemedicine use among Black individuals compared to White individuals, while reductions among Hispanic and Asian individuals were not statistically significant. Furthermore, individuals with higher education levels, those residing in urban areas, and those with private insurance demonstrated greater use of telemedicine services.

##### Comparison with other studies

This finding suggests that, in general, males are less likely to use telemedicine compared to their female counterparts. These results are consistent with recent studies [42], [43], [44]. This trend can be attributed to several factors. Women are more actively engaged with healthcare services, including preventive care, chronic condition management, and mental health support, not only for themselves but also for their children and elderly family members. [45] This increased responsibility makes telemedicine a valuable tool, offering a convenient and efficient way to manage healthcare. Therefore, telemedicine provides essential support, empowering women to prioritize their health and the well-being of themselves and their families. [46], [47]

Additionally, our review found that older adults have lower rates of telemedicine use compared to younger adults in primary care settings. This aligns with existing research, which shows that older adults frequently encounter barriers such as limited access to telemedicine services, low technology literacy, and concerns about 1 and security, all of which contribute to slower adoption rates [48], [49], [50]. This is a significant finding, especially considering that the population of people aged 60 and older from minority backgrounds is projected to increase by 80% since the 2011 census. [51] Addressing these barriers is crucial to ensure that older adults can benefit from the convenience and accessibility of telemedicine.

Moreover, this review highlights a significant disparity in telemedicine use, with adults of lower educational levels being 70% less likely to utilize these services compared to their more educated counterparts. This disparity may be attributed to barriers such as limited access to technology, low digital and health literacy, and concerns about trust and privacy. [52], [53], [54] These challenges are particularly concerning given the higher prevalence of chronic conditions like Type 2 diabetes among lower socioeconomic groups, who often have lower educational levels. This underscores the urgent need to improve telemedicine accessibility to ensure equitable healthcare access for all. [55], [56]

Although many studies highlight the potential of telemedicine for racial and ethnic minorities, [57], [58], [59] this meta-analysis showed a statistically significant 45% reduction in telemedicine use among Black individuals compared to White individuals, while reductions among Hispanic and Asian individuals were not statistically significant. Notably,

evidence of heterogeneity was detected in the analysis concerning racial disparities, likely due to variations in the study population, data source, exposure definition, and analytical approaches. Nevertheless, the summarized evidence indicates that racial disparities in telemedicine use remain a significant public health challenge [12], [60], [61]. Therefore, it is crucial to identify factors that adversely affect telemedicine use among racial and ethnic minorities, with the digital divide being one of the key factors that may play a significant role.[62] The digital divide highlights that many people, especially those from minority backgrounds, lack affordable access to the necessary technology, such as computer, smartphone, and broadband access. [63] [64] These findings highlight the importance of understanding the patterns of health-related technology use across racially and ethnically diverse populations to appropriately tailor interventions aimed at improving minority health and eliminating health disparities. By understanding these disparities and addressing the underlying factors, we can develop more inclusive and effective telemedicine interventions.

#### **Strengths and limitations of the study**

This review has several notable strengths, including the inclusion of studies with relatively large sample sizes and methodological rigor, which significantly strengthen the overall analysis. However, several limitations must be acknowledged. Firstly, only a few studies explicitly examined racial and ethnic disparities, revealing a significant research gap that highlights the urgent need for more inclusive and diverse research. Secondly, all included studies were conducted in developed countries, which limits the generalizability of the findings and excludes valuable research from low- and middle-income countries (LMICs). Finally, there was evidence of substantial heterogeneity among the studies, which complicates drawing definitive conclusions.

#### **Policy implications and future research**

Our findings highlight the urgent need for policymakers, healthcare systems, and stakeholders to prioritize reducing disparities in telemedicine utilization among individuals with T2DM. This condition disproportionately affects historically underserved populations, exacerbating their vulnerability to severe complications. Addressing these disparities requires targeted strategies and the development of robust policies for key demographic groups, including males, older adults, ethnic minorities, individuals with limited education, those reliant on public insurance, and residents of rural or underserved communities. These populations face significant barriers to telemedicine adoption including technological and socioeconomic challenges that exacerbate disparities in access and, consequently, health outcomes

Moreover, significant research gaps persist in understanding other critical factors driving these disparities, particularly the roles of the digital divide, health literacy, digital literacy, and language barriers. To tackle these issues effectively, comprehensive research is necessary to explain the structural and individual-level determinants that hinder telemedicine adoption and utilization. This research will provide the insights needed to design effective and robust interventions. These interventions must include co-design approaches involving both patients and healthcare providers. Patients bring essential insights into lived experiences and challenges, while providers can identify systemic barriers and contribute to designing pragmatic, scalable solutions.

To build a resilient telemedicine infrastructure, we need sustained support for healthcare organizations, adherence to complex legal and regulatory frameworks, equitable and consistent funding mechanisms, and culturally tailored community engagement. Such foundational measures will ensure that telemedicine is not only accessible but also equitable

and sustainable. Moreover, a multi-pronged strategy is needed, framed within the principles of established frameworks. [65] This includes addressing structural barriers, promoting digital equity, enhancing research efforts, and fostering collaboration between patients and providers. [66] These approaches align with the American Medical Association's Return on Health: Telehealth Framework, which emphasizes the importance of closing digital gaps and creating fair, inclusive telemedicine systems. [67] Investments in telemedicine infrastructure should include training programs for healthcare providers, improved access to digital technologies for underserved populations, and communication campaigns highlighting telemedicine's benefits, such as reduced travel times and timely care access. Such measures are particularly critical for older adults and other high-risk groups. [68] Building trust in telemedicine systems and addressing fears around technology adoption, within the scope of this framework, are key to driving greater utilization and improving health outcomes.[69]

There is an urgent need to address evidence gaps in LMICs), where socio-economic and demographic inequalities are often underrepresented in telemedicine research.[69] Policymakers must prioritize investing in targeted research to better understand the barriers faced by underserved populations in these communities. This includes funding studies that capture the socio-cultural, economic, and technological factors influencing telemedicine utilization. By supporting robust data collection, promoting cross-sector collaboration, and ensuring equitable distribution of resources, policymakers can bridge these critical gaps. These actions will enable the development of inclusive telemedicine solutions tailored to the unique needs of LMICs, ultimately improving healthcare equity and access for the most vulnerable populations.

This systematic review and meta-analysis represent the first comprehensive effort to directly examine disparities in telemedicine utilization among individuals with T2DM. Despite its contribution, there remains a significant need for further studies investigating the social, structural, and technological determinants of these disparities. Evidence-based policy reforms informed by robust research are crucial for developing inclusive and tailored telemedicine solutions that advance healthcare equality.

### **Conclusion**

This systematic review and meta-analysis provide evidence of significant disparities in telemedicine utilization among men, older adults, Black individuals, and those with lower levels of education who have T2DM in primary care. Given that these groups are among the most vulnerable to T2DM, these disparities highlight the critical need for strategic interventions and robust policy that ensures telemedicine fosters equitable access to healthcare, while preventing further exacerbation of existing health inequalities. Moreover, we strongly urge further studies in this area, as we anticipate telemedicine will remain a critical care modality for individuals with T2DM in the coming years. Policymakers and healthcare stakeholders must take proactive measures to mitigate disparities, enhance access, and ensure that telemedicine fulfils its potential to improve outcomes for all individuals with T2DM.

### **Author contributions**

NA, EK, AH, and MP were involved in the design and concept of this study. NA conducted the systematic literature search, data extraction, the analysis and wrote this article. MP, AH and EK were involved in study selection and EK was involved in data extraction. NA, EK, AH, MP, LH and SZ contributed to the drafting the final article.

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#### **CONFLICT OF INTEREST STATEMENT**

None declared.

#### **Patient and public involvement**

Patients and/or the public were not involved in the design, conduct or reporting or dissemination plans of this research.

#### **Patient consent for publication**

Not required.

#### **PROVENANCE AND PEER REVIEW**

Not commissioned.

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## Appendix

| Study           | Risk of bias domains |    |    |    |    |    |    | Overall |
|-----------------|----------------------|----|----|----|----|----|----|---------|
|                 | D1                   | D2 | D3 | D4 | D5 | D6 | D7 |         |
| Roelofsen, 2014 | +                    | +  | +  | +  | -  | +  | +  | -       |
| Ronda, 2013     | +                    | +  | +  | +  | +  | +  | +  | +       |
| Robinson, 2022  | +                    | +  | +  | +  | X  | +  | +  | X       |
| Ronda, 2014     | +                    | +  | +  | +  | -  | +  | +  | -       |
| Shields, 2023   | +                    | +  | +  | +  | -  | +  | +  | -       |
| Conway, 2019    | +                    | +  | +  | +  | -  | +  | +  | -       |
| Lyles, 2012     | +                    | +  | +  | +  | +  | +  | +  | +       |
| Sarkar, 2010    | +                    | +  | +  | +  | -  | +  | +  | -       |
| Haynes, 2021    | +                    | +  | +  | +  | -  | +  | +  | -       |
| Mathieson, 2017 | -                    | +  | +  | +  | +  | +  | +  | +       |
| Ronda, 2015     | +                    | +  | +  | +  | X  | +  | +  | X       |
| Sarkar, 2007    | +                    | +  | +  | +  | -  | +  | +  | -       |
| Semere, 2019    | +                    | +  | +  | +  | X  | +  | +  | X       |
| Cho, 2010       | +                    | +  | +  | +  | +  | +  | +  | +       |
| Coughlin, 2018  | +                    | +  | +  | +  | -  | +  | +  | -       |
| Sun, 2019       | +                    | +  | +  | +  | +  | +  | +  | +       |

Domains:  
 D1: Bias due to confounding.  
 D2: Bias due to selection of participants.  
 D3: Bias in classification of interventions.  
 D4: Bias due to deviations from intended interventions.  
 D5: Bias due to missing data.  
 D6: Bias in measurement of outcomes.  
 D7: Bias in selection of the reported result.

Judgement  
 X Serious  
 - Moderate  
 + Low

Figure 2 Risk of bias assessment using ROBINS-I.

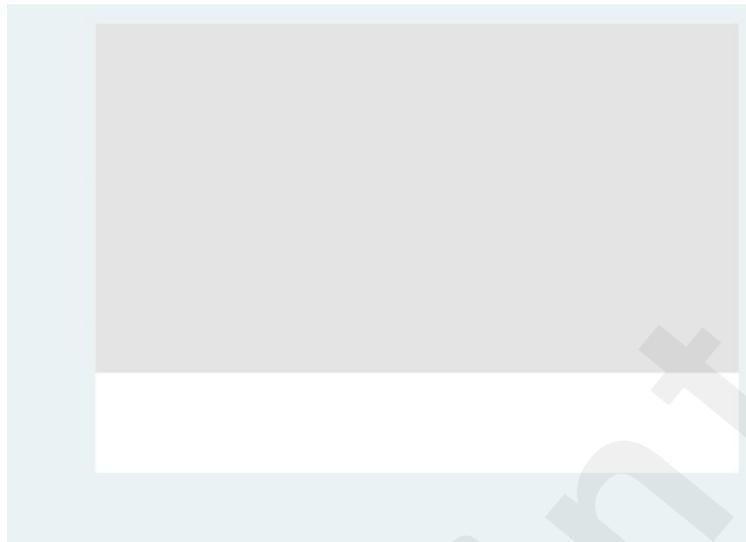


Figure 4  
Funnel plot (Egger's test) of studies testing association between gender/sex and the use of telemedicine intervention ( $n = 10$ ) for publication bias; Egger's test:  $P = 0.672$ .

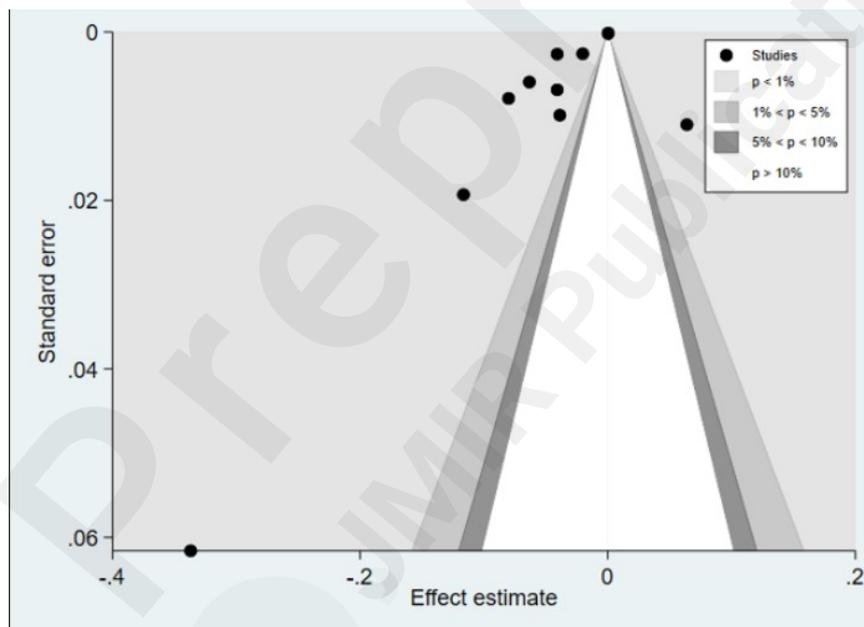


Figure 6  
Funnel plot of studies testing association between age and the use of telemedicine ( $n = 10$ ) for publication bias; Egger's test: ( $P < 0.001$ ).

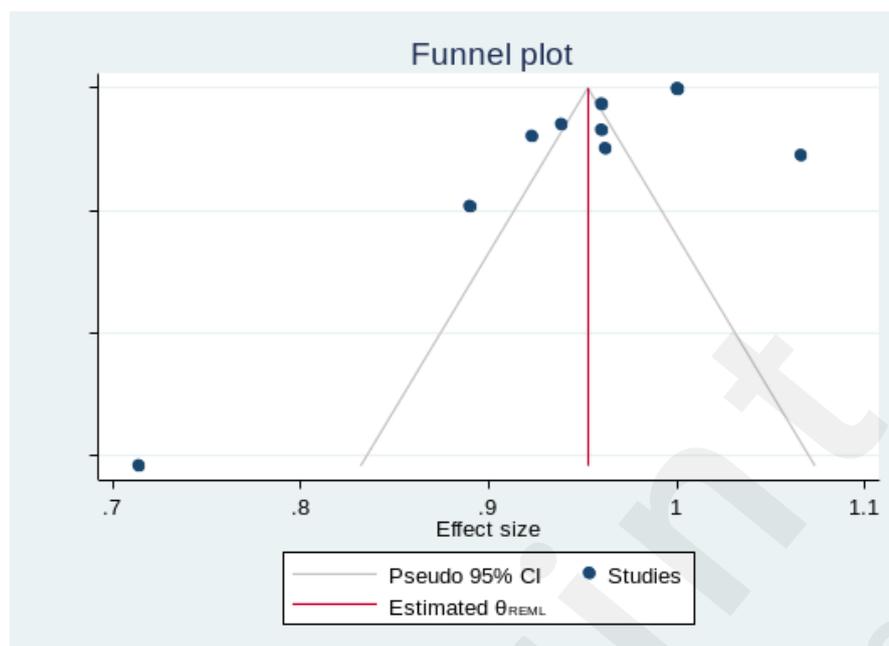


Figure 7  
 Funnel plot (trim-and-fill) of studies testing association between age and the use of telemedicine in primary care (n = 10).

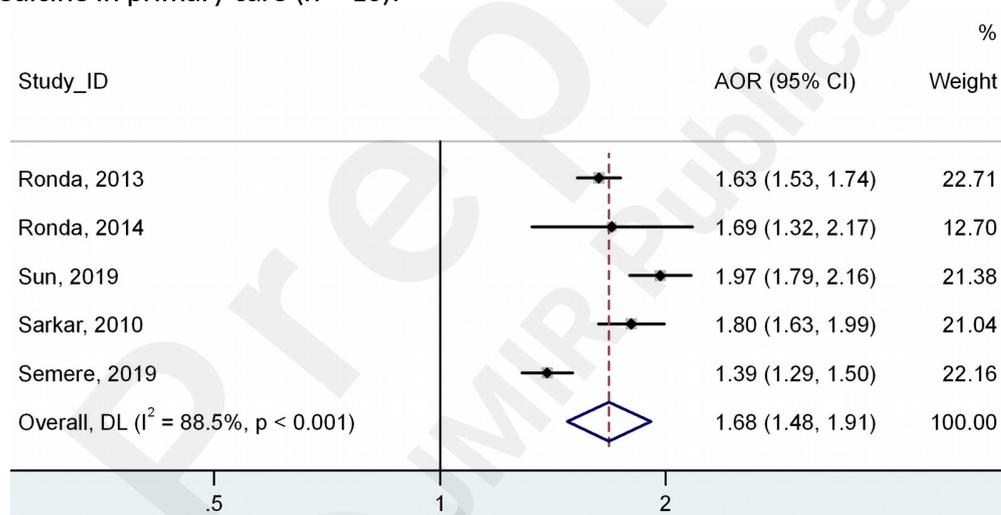


Figure 12  
 Forest plot of the meta-analysis examining the association between education and the use of telemedicine in primary care (n = 5). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity:  $I^2 = 88.5\%$ .

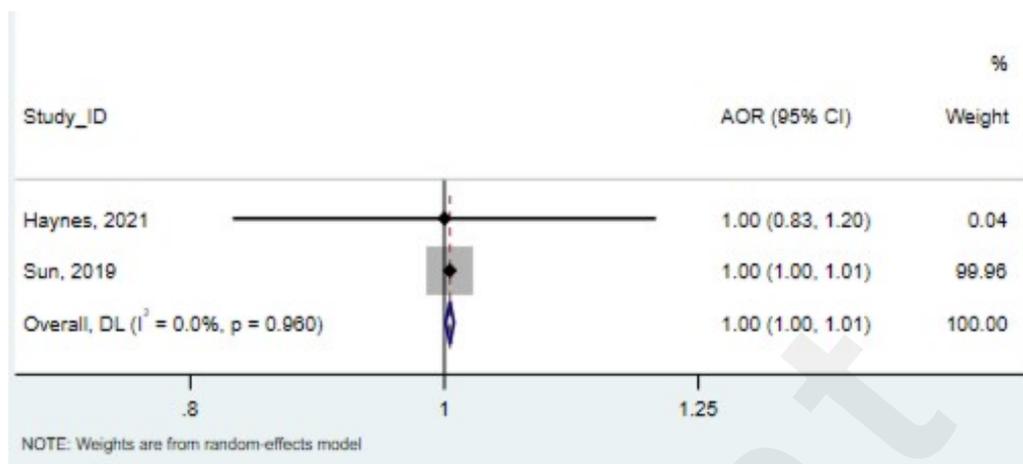


Figure 13

Forest plot of the meta-analysis examining the association between education and the use of telemedicine in primary care (n = 5). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity:  $I^2 = 88.5\%$ .

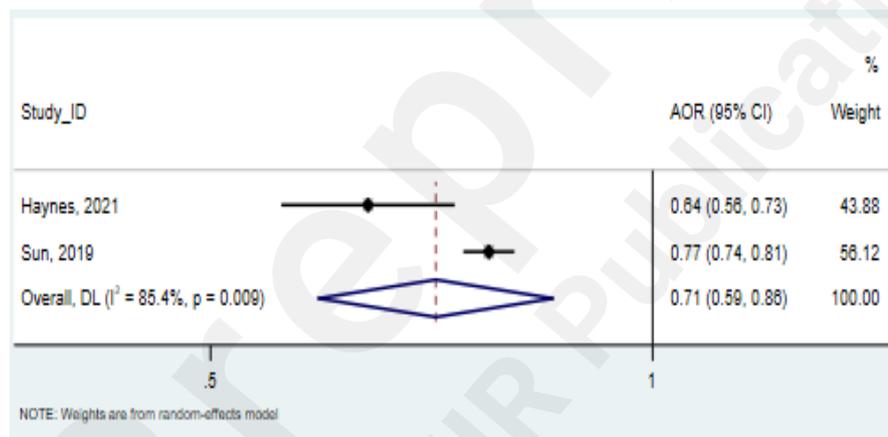
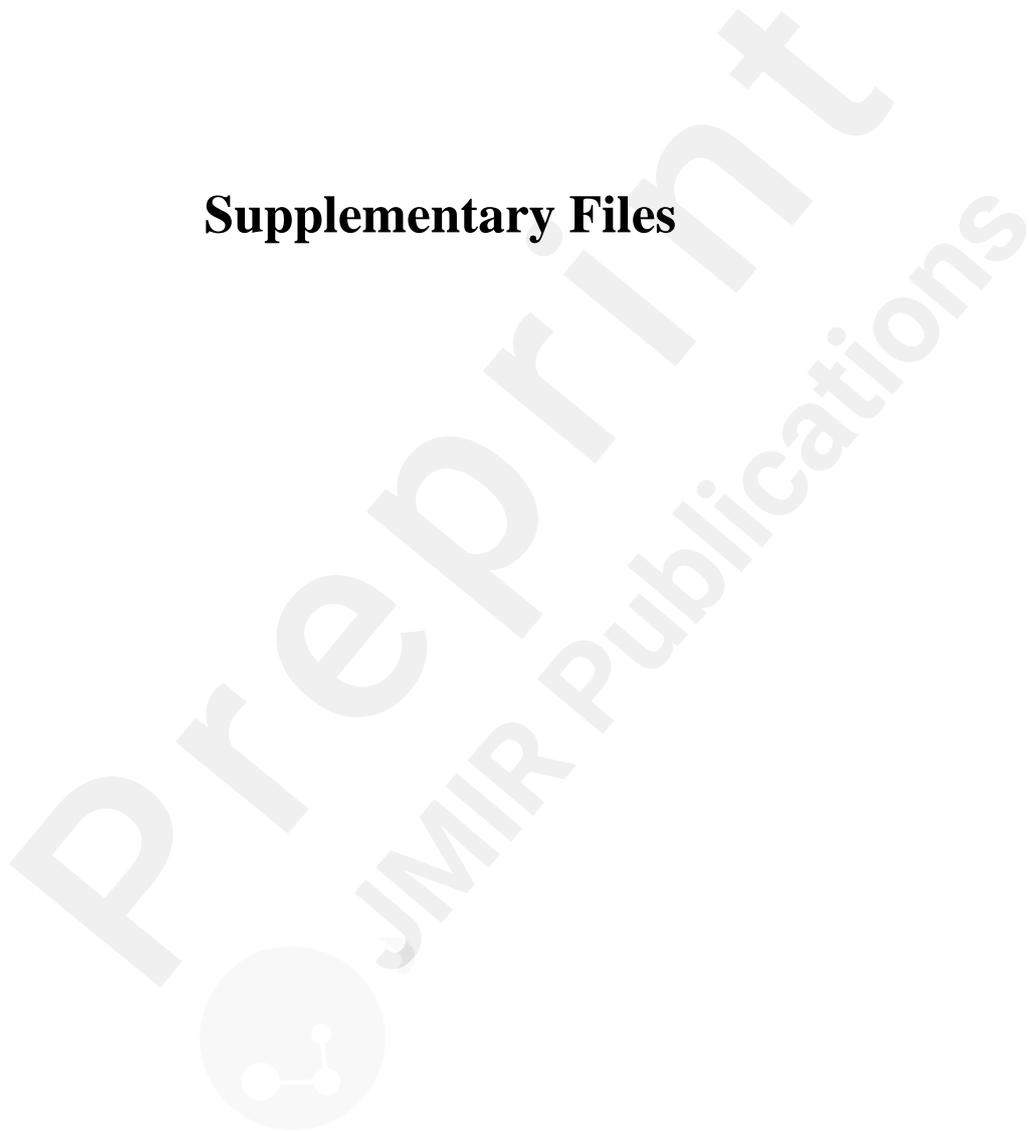


Figure 14

Forest plot of the meta-analysis examining the association between insurance type and the use of telemedicine in primary care (n = 5). The plot displays study-specific and summary effect estimates, including odds ratios (OR) and 95% confidence intervals (CI). Heterogeneity  $I^2 = 85.4\%$ .

## Supplementary Files



## Multimedia Appendixes

Untitled.

URL: <http://asset.jmir.pub/assets/ce9e9212d6ec1f607c379a9def427c78.docx>

Untitled.

URL: <http://asset.jmir.pub/assets/a4548eb64d87e9b1043266f5c5870d53.xlsx>

Untitled.

URL: <http://asset.jmir.pub/assets/c32747ba4f5c43e0f32a8aee7574285e.docx>