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Role of telemedicine during COVID-19 pandemic in type 2 diabetes outpatients: The AMD annals initiative

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ABSTRACT

Aims: Telemedicine is advocated as a fundamental tool in modern clinical management. However, data on the effects of telemedicine vs face-to-face consultation on clinical outcomes in type 2 diabetes (T2DM) are still uncertain. This paper describes the use of telemedicine during the 2020 COVID-19 emergency and compares volume activity and quality indicators of diabetes care between face-to-face vs telemedicine counseling in the large cohort of T2DM patients from the AMD Annals Initiative.

Methods: Demographic and clinical characteristics, including laboratory parameters, rate of the screening of long-term complications, current therapies and the Q-score, a validated score that measures the overall quality of care, were compared between 364,898 patients attending face-to-face consultation and 46,424 on telemedicine, during the COVID-19 pandemic.

Results: Patients on telemedicine showed lower HbA1c levels (7.1 ± 1.2 % vs 7.3 ± 1.3 %, $p < 0.0001$), and they were less frequently treated with metformin, GLP1-RAs and SGLT2i and more frequently with DPP4i. The telemedicine group showed reduced monitoring of the various parameters considered as process indicators, especially, eye and foot examination. The proportion of patients with a good quality of care (Q score > 25) was higher among those receiving face-to-face consultation.

Moreover, in the telemedicine group, all major clinical outcomes remained stable when further compared to those collected in the year 2019, when the same patients underwent a regular face-to-face consultation, suggesting that the care provided through telemedicine did not negatively affect the most important parameters.

Conclusions: During the COVID-19 pandemic, telemedicine provided an acceptable quality of diabetes care, comparable to that of patients attending face-to-face consultation, although a less frequent screening of complications seems to have occurred in subjects consulted by telemedicine.

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1. Introduction

Telemedicine is defined as the use of electronic information and telecommunication technology to deliver health care, including direct patient care, health education, and population health management. Virtual health care and telemedicine platforms provide chronic disease patients with enhanced access to medical services compared with the pre-technological era. Telemedicine has been widely recognized for decades as a valuable method of improving access to health care services that would otherwise be difficult to obtain, perhaps due to location (rural and remote) or other barriers (frailty, lack of transportation, or other physical or mental health conditions) [1].

The COVID-19 pandemic accelerated an already ongoing process of digital transformation in healthcare and posed new challenges and opportunities to patients and their families to respond to the epidemic, given its advantages in terms of non-face-to-face medical treatment, no limits of time and space, and the feasibility of traceable follow-up visits. All potential advantages that could be particularly desirable during the COVID-19 pandemic, especially for patients with chronic diseases, such as those with diabetes mellitus (DM), who are at higher risk of developing severe forms of COVID-19 infection and/or dying for it [2,3].

The role of telemedicine has been partly explored also before the pandemic. Thus, previous studies have shown its efficacy in improving glycemic control, weight reduction, dyslipidemia, diabetic foot care, and patient satisfaction [4–6].

However, prior to the pandemic emergency, telemedicine has been predominantly tested in clinical studies assessing its feasibility, predominantly for few, digitally friendly patients, especially young subjects affected by type 1DM (T1DM) [7].

Moreover, a successful approach with telemedicine in the long-term should involve precise standards for best practices and the optimization of data collection and share, all requirements that were not uniformly incorporated in the clinical practice before the COVID-19 emergency.

In order to respond to this need, in the first week of the COVID-19 pandemic, the Italian scientific societies involved in the management of diabetes: the Association of Medical Diabetologists (AMD), the Italian Society of Diabetes (SID) and the Italian Society of Endocrinology (SIE), released a position statement for the adoption of telemedicine for people with type 2 DM (T2DM), T1DM, and gestational diabetes (GDM) [8].

In spite of these recommendations, in the first wave of the pandemic, the telemedicine approach seldom used structured and dedicated platforms but, in the real-world clinical practice, it involved a spontaneous use of telephone calls, emails, video-calls by diabetologists, who did not want to leave their DM patients alone without a guide.

Thus, in Italy, specialist care for individuals with T2DM is mainly provided by a public network of 700 diabetes clinics that, by using electronic medical records, offers the possibility of rapidly recording information on medical history, laboratory tests, current drugs use, glucometers data sharing, therefore allowing a remote visit through telemedicine.

The spread use of telemedicine approach during the COVID-19 pandemic offered an opportunity to evaluate the potential benefits /arms of this approach on unselected T2DM subjects, irrespective of age, technological literacy and clinical complexity, all aspects that have not been evaluated before in large-scale studies, an information that is clinically relevant before recommending its routinely use as a structured tool in the clinical management of T2DM patients.

Accordingly, the principal aim of this study was to describe the use of telemedicine during the COVID-19 pandemic in the year 2020, and to examine its impact on the volume activity and quality of diabetes care in the large cohort of T2DM patients participating to the AMD Annals Initiative, an ongoing study involving ~ 1/3 of diabetes clinic in Italy [9–11].

In particular, clinical and demographic characteristics, laboratory parameters, pharmacological treatment, quality of care indicators, including the rate of screening of long-term complications and the Q-score, a validated score that measures quality of care and associated-cardiovascular risk [9–14], were compared between T2DM patients who attended a face -to -face counseling vs those managed by remote telemedicine.

Moreover, to assess whether the management of diabetes through telemedicine had decreased the quality of care, a second aim of the study was to compare, in the group of patients receiving telemedicine consultation during the year 2020, quality of care indicators vs those in the previous year (2019), when the same patients received face- to- face consultation.

2. Patients and methods

The Association of Medical Diabetologists-AMD is an Italian scientific association of clinical diabetologists with the mission of measuring and improving the quality of diabetes care. In 2006, AMD established a continuous quality improvement initiative involving diabetes centers throughout Italy (AMD Annals initiative). The methodology of the AMD Annals initiative has been previously described [9–14]. Briefly, AMD identified a set of quality of care indicators to be used for benchmarking activities. Quality indicators include process measures evaluating diagnostic, preventive and therapeutic procedures performed by the participating centers, and outcome indicators measuring favorable and unfavorable modifications in the patient health status. Furthermore, the use of glucose-lowering, antihypertensive, and lipid-lowering drugs is evaluated. A software package specifically developed for the project enabled the extraction from clinical databases of the information (AMD Data File) needed for the evaluation of process and outcomes indicators. Each individual center had the possibility of measuring its performance directly from the electronic record system, using an ad hoc software package, allowing the comparison with the performance of the whole sample or that of best performers.

Moreover, data from all participating centers were collected and centrally analyzed anonymously.

In particular, data on T2DM complications and current medications were also collected.

Diabetes complications were classified according to ICD-9 CM codes.

Microalbuminuria was defined as albumin excretion rate > 20 mcg/min, albumin/creatinine ratio > 2.5 (men) or > 3.5 (women) mg/mmol, or microalbuminuria > 30 mg/l. GFR was calculated with the Chronic Kidney Disease Epidemiology Collaboration (CKD-*EPI*) formula [15].

Classes of drugs were identified according to their Anatomical Therapeutic Chemical Classification System (ATC) codes.

A comprehensive list of all centers participating in the study can be accessed as supplementary information. (Please see supplementary material).

2.1. Quality of care indicators

Process measures are expressed as percentages of patients monitored at least once during the index year for the following parameters: HbA1c, blood pressure (BP), lipid profile (LDL cholesterol or total and HDL cholesterol, and triglycerides). In patients on telemedicine, BP values were self-monitored.

Also, the rate of monitoring of renal function, foot examination, and eye examination was included among quality of diabetes care indicators.

Intermediate outcome measures include the proportion of patients with satisfactory values (favorable outcomes) as well as the percentage of those with unacceptably high values (unfavorable outcomes). Outcomes are considered satisfactory if HbA1c levels are ≤ 7.0 % (≤53 mmol/mol), BP values are ≤ 140/90 mmHg, and LDL cholesterol (LDL-c) levels are < 100 mg/dl. Unsatisfactory outcomes include HbA1c levels > 8.0 %, BP values > 140/90 mmHg, LDL levels > 130 mg/dl, presence of micro-/macro-albuminuria, and glomerular filtration rate (GFR) < 60 ml/min.

Indicators of treatment intensity/appropriateness take into consideration the use of pharmacologic treatments in relation to the level of the clinical parameters: no insulin therapy despite HbA1c > 9.0 %, [75 mmol/mol), no lipid lowering agents despite LDL-c ≥ 130 mg/dl, no antihypertensive treatment despite BP ≥ 140/90 mmHg, no ACE inhibitors (ACE-I) and/or angiotensin receptor blockers (ARBs) despite micro-/macroalbuminuria, HbA1c > 9.0 % [75 mmol/mol) in spite of insulin treatment, LDL-c ≥ 130 mg/dl in spite of lipid-lowering treatment, and BP ≥ 140/90 mmHg in spite of antihypertensive treatment.

2.2. Q score

A quality of care summary score (Q score) ~~is~~ was calculated. The Q score has been developed and validated in two previous studies [11,12] and integrated in the AMD Annals initiative since the 2009 edition. The score is based on a combination of process and outcome indicators relative to HbA1c, blood pressure, LDL-C, and microalbuminuria. The score ranges between 0 and 40; the higher the score, the better the quality of care. In the two previous studies [9,11], the Q-score was closely related to long-term outcomes. In fact, the risk of developing a new cardiovascular event was 80 % higher in patients with a score < 15 and 20 % higher in those with a score between 15 and 25, as compared with those with a score > 25. Furthermore, a low Q score was associated with greater variability in clinical parameters (HbA1c, blood pressure, uric acid, lipid parameters); such a variability is in turn associated with a greater risk of diabetes complications [14].

2.3. Sample selection and data analyses

Clinical data collected during the years 2019 and 2020 were extracted from electronic medical records of participating diabetes clinics. Patients with diagnosis of T2DM were selected for this analysis. In 2020, we compared quality indicators of patients contacted through telemedicine vs those receiving a face-to-face counseling in the diabetes clinic. The comparison was done by excluding patients who used both approaches (face to face first and then telemedicine).

Furthermore, for patients contacted through telemedicine, we compared quality indicators of 2019 vs quality indicators in 2020.

Subjects on telemedicine counselling were identified by a specific annotation of telemedicine visit in the patient's electronic chart.

In case of multiple records collected during the same year for the same patient, the last available value was included in the quality of care profiling. Denominators for the different quality indicators vary according to the availability of the information in the index year (Supplementary Table 2). No missing imputation was performed.

2.4. Statistical analysis

Patients' characteristics were described as mean and standard deviation or frequencies. Quality indicators are expressed as crude percentages.

Patient characteristics and quality indicators of the two groups, i.e. face to face consultation vs telemedicine consultation, were compared through the chi-squared test for categorical variables and T-test for continuous variables. Pre-post comparisons (2020 vs 2019) in face to face consultation group were based on McNemar test for categorical variables and paired T-test for continuous variables. All statistical analyses were performed with SAS software, version 9.4 (SAS Institute Inc., Cary, NC). p-values < 0.05 was considered statistically significant.

3. Results

During 2020, a total of 364,898 T2DM patients attended the diabetes clinic at least once, while 46,424 patients were contacted through telemedicine systems. Patient characteristics according to the kind of consultation are reported in Table 1. As for sex distribution and age, patients on telemedicine were more frequently women (p < 0.0001) and ~ 2-years older than those who attended a face-to-face consultation (p < 0.0001), with those > 75 years old being particularly represented (39.6 % vs 32.2 %).

Patients on telemedicine also showed slightly better metabolic control (HbA1c (%): 7.1 ± 1.2 vs 7.3 ± 1.3, p < 0.0001), in spite of the only minor differences in terms of glucose-lowering treatment between the two groups (Table 2).

BMI was comparable between the two groups (p 0.10), while systolic and diastolic blood pressure values were lower in the telemedicine patients. Patients on telemedicine showed higher values of total cholesterol, LDL-C and lower levels of HDL-C and triglycerides. The overall persistence of smoking habit is alarming, with a slightly higher prevalence in face-to-face patients (17.4 % vs 15.6 % in telemedicine, p < 0.0001).

Renal function merits also a specific consideration: worse glomerular filtration values were noted in remote patients compared to those seen face to face (eGFR < 60 ml/ min in 33.6 % of remote subjects vs 29.6 % in presence, p < 0.0001).

No major differences between patients receiving face to face consultations and those contacted from remote emerged as for the prevalence of major complications, with some differences for retinopathy, stroke and foot complications.

Table 2 shows current drugs use. Compared to patients receiving face to face consultations, those in the telemedicine group were less frequently treated with metformin (67.9 % vs 71.9 %, p < 0.0001), GLP1-RA (12.0 % vs 15.7 %, p < 0.0001), and SGLT2i (13.2 % vs 16.6 %, p < 0.0001) and more frequently treated with DPP4i (24.5 % vs 22.6 %, p < 0.0001). No differences emerged as for the proportion of patients treated with insulin. Patients contacted from remote were also less frequently treated with antihypertensive and lipid-lowering drugs.

Table 3 reports quality of care indicators. The telemedicine group showed lower rates of monitoring of the various parameters considered as process indicators. As expected, eye examination and foot examination were performed in a minority of patients in the telemedicine group (11.5 % and 4.3 %, respectively); however, these indicators were

Table 1
T2DM patient characteristics according to the type of consultation.

Characteristics	Face to face consultation	Telemedicine consultation	P value
n (%)	364,898	46,424	
Age (years)	69.1 ± 11.1	71.3 ± 11.2	<0.0001
Sex (% males)	58.6	54.1	<0.0001
Smoking (%)	17.4	15.6	<0.0001
Duration of diabetes (years)	12.6 ± 9.6	12.8 ± 9.5	<0.0001
HbA1c (%)	7.3 ± 1.3	7.1 ± 1.2	<0.0001
BMI (kg/m^2)	29.4 ± 5.5	29.3 ± 5.5	0.10
Systolic blood pressure (mmHg)	136.7 ± 18.7	133.1 ± 16.7	<0.0001
Diastolic blood pressure (mmHg)	77.3 ± 10.0	76.1 ± 9.7	<0.0001
Total cholesterol (mg/dl)	166.6 ± 39.0	177.6 ± 38.2	<0.0001
LDL cholesterol (mg/dl)	89.4 ± 32.5	91.3 ± 32.0	<0.0001
HDL cholesterol (mg/dl)	48.8 ± 13.0	49.2 ± 13.2	<0.0001
Triglycerides (mg/dl)	142.0 ± 85.0	135.6 ± 78.4	<0.0001
Diabetes complications			
Retinopathy (%)	16.6	14.1	<0.0001
Cardiovascular disease* (%)	14.7	14.7	0.94
Myocardial infarction (%)	7.6	7.6	0.70
Stroke (%)	2.5	3.1	<0.0001
Foot complications** (%)	0.5	0.4	<0.0001
eGFR < 60 ml/min (%)	29.6	33.6	<0.0001
Dialysis (%)	0.3	0.3	0.55

Data are n (%) and mean ± SD. *CVD, myocardial infarction/stroke/ coronary or peripheral revascularization/ coronary or peripheral bypass. Only significant P-values are shown.

Table 2
Current drug use in T2DM patients according to the type of consultation.

Treatment	Face to face consultation	Telemedicine consultation	P value
Therapeutic scheme			
No pharmacological treatment	3.4	4.8	<0.0001
GLP1-RA + other	15.7	12.0	
Oral monotherapy	24.1	26.5	
Dual oral	21.3	21.6	
≥3 oral agents	6.8	6.4	
Insulin + oral agents	16.9	15.2	
Insulin	11.7	13.6	
Glucose lowering drugs			
Metformin	71.9	67.9	<0.0001
Sulphonylureas	12.8	12.6	0.20
Glinides	2.2	2.0	0.002
Pioglitazone	4.5	4.0	<0.0001
Acarbose	1.8	2.1	<0.0001
DPP4i	22.6	24.5	<0.0001
GLP1-RAs	15.7	12.0	<0.0001
SGLT2i	16.6	13.2	<0.0001
Basal insulin	29.5	28.5	<0.0001
Short acting insulin	19.4	19.4	0.91
Anti-hypertensive drugs	69.6	60.7	<0.0001
Lipid lowering drugs	63.0	52.2	<0.0001

Data are n (%).

suboptimal also among patients receiving face to face consultations (eye examination: 25.1 %, foot examination: 14.3 %). Also monitoring of HbA1c, lipid profile, BP, albuminuria, and serum creatinine were significantly lower in the telemedicine group.

Favorable intermediate outcome indicators show that the telemedicine group was more likely to present good metabolic control and blood pressure control. Unfavorable outcome indicators confirmed a better profile for patients receiving remote consultation, with the only exception of a slightly higher percentage of subjects with eGFR < 60 ml/min, likely related to the older age of this group.

The analysis of indicators of treatment intensity/appropriateness shows mixed results (Table 3). Patients in the telemedicine group were less likely not to receive insulin treatment in the presence of HbA1c levels ≥ 9.0 % (>75 mmol/mol). On the other hand, they were more likely not to receive antihypertensive and lipid-lowering treatment in the presence of elevated blood pressure and LDL-C levels. Among patients treated with insulin, those in the telemedicine group were less likely to present HbA1c levels ≥ 9.0 % (>75 mmol/mol); also, among patients treated with antihypertensive drugs, those receiving remote consultation were less likely to show blood pressure levels ≥ 140/90 mmHg. Finally, the proportion of patients with a Q score > 25 was higher among patients receiving face to face consultation.

To assess whether the management of diabetes through telemedicine had decreased the quality of care, in the group of patients receiving telemedicine consultation during the year 2020, quality of care was compared with those in the previous year (2019), when the same patients received fate to face consultation (Table 4).

The table shows that all outcomes remained stable in 2020 as compared to 2019, suggesting that the care provided through telemedicine did not negatively affect the level of control of the most important parameters. As for diabetes treatment, compared to 2019, in 2020 there was a slight increase in the number of patients treated with GLP1-RA, SGLT2i, and insulin, and a marginal decrease in the proportion of patients treated with metformin, secretagogues, acarbose, and DPP4i.

4. Discussion

The scope of the current analysis of the AMD Annals, was to assess the impact of telemedicine in patients with T2DM during the COVID-19 pandemic, by measuring the volume of activity and evaluating the quality of care delivered via telemedicine by specialists.

Table 3
Quality of care indicators of T2DM management by type of consultation.

Quality of care indicators	Face to face consultation	Telemedicine consultation	P value
Process indicators[a]			
HbA1c	94.7	82.0	<0.0001
Blood pressure	80.4	30.9	<0.0001
Lipid profile	75.7	61.0	<0.0001
Albuminuria	64.9	53.0	<0.0001
Serum creatinine	88.3	76.3	<0.0001
Eye examination	25.1	11.5	<0.0001
Foot examination	14.3	4.3	<0.0001
Favorable outcome indicators			
HbA1c ≤ 7.0 % (≤53 mmol/mol)	48.8	56.0	<0.0001
Blood pressure < 140/90 mmHg	50.3	60.7	<0.0001
LDL cholesterol < 100 mg/dl	66.5	64.4	<0.0001
Unfavorable outcome indicators			
HbA1c > 8.0 % (>64 mmol/mol)	21.8	16.1	<0.0001
Blood pressure ≥ 140/90 mmHg	49.7	39.3	<0.0001
LDL cholesterol ≥ 130 mg/dl	11.4	12.1	0.001
Albuminuria	33.6	32.7	0.006
eGFR < 60 ml/min	29.6	33.6	<0.0001
Indicators of treatment intensity/appropriateness			
No insulin despite HbA1c ≥ 9.0 % (>75 mmol/mol)[*]	29.4	23.3	<0.0001
No antihypertensive treatment despite BP ≥ 140/90 mmHg[**]	27.0	29.6	<0.0001
No lipid-lowering agents despite LDL-cholesterol ≥ 130 mg/dl[***]	45.3	52.7	<0.0001
No ACE-I and/or ARBs despite albuminuria[£]	38.4	40.3	<0.0001
HbA1c ≥ 9.0 % (≥75 mmol/mol) in spite of insulin treatment[§]	19.3	14.8	<0.0001
BP ≥ 140/90 mmHg in spite of antihypertensive treatment[¤]	51.6	40.4	<0.0001
LDL-cholesterol ≥ 130 mg/dl in spite of lipid lowering treatment[ǂ]	9.5	9.7	0.42
Overall quality of care			
Q score > 25	56.4	49.5	<0.0001

[a] Process indicators, percentages of patients monitored at least once during the index year for the following parameters. Data are n (%).
[*] The denominator is represented by all patients with HbA1c ≥ 9.0 %.
[**] The denominator is represented by all patients with BP ≥ 140/90 mmHg.
[***] The denominator is represented by all patients with LDL- cholesterol ≥ 130 mg/dl.
[£] The denominator is represented by all patients with albuminuria.
[§] The denominator is represented by all patients treated with insulin.
[¤] The denominator is represented by all patients treated with antihypertensive drugs.
[ǂ] The denominator is represented by all patients treated with lipid-lowering drugs.

Data collected from 282 diabetes centres scattered all over Italy showed that patients who were followed remotely had no clinically meaningful differences in terms of therapeutic prescriptions and metabolic parameters, when compared to the group in presence. Overall, the telemedicine approach, although performed through unstructured and diverse ways from centre to centre, was able to maintain an acceptable quality of care, without clinical differences in terms of metabolic profile, diabetes complications and quality of care indicators. This trend was further conformed when clinical data of T2DM patients, who underwent telemedicine consultation during the pandemic year 2020 were compared with those of the same patients during the previous year, with the only exception of an increase in the prescription of "newer" hypoglycaemic drugs in the most recent year. The COVID-19 emergency has

Table 4
Comparison of intermediate outcomes and glucose-lowering treatment between 2019 and 2020 in T2DM patients contacted through telemedicine in 2020.

Quality indicators	2019	2020	P value
Intermediate outcomes			
HbA1c (%)	7.1 ± 1.2	7.1 ± 1.2	<0.0001
BMI (kg/m^2)	29.2 ± 5.4	29.3 ± 5.5	0.03
Systolic blood pressure (mmHg)	134.5 ± 17.8	133.1 ± 16.7	<0.0001
Diastolic blood pressure (mmHg)	76.6 ± 9.7	76.1 ± 9.7	<0.0001
Total cholesterol (mg/dl)	168.4 ± 37.2	177.6 ± 38.2	0.0003
LDL cholesterol (mg/dl)	92.2 ± 31.5	91.3 ± 32.0	<0.0001
HDL cholesterol (mg/dl)	49.1 ± 13.1	49.2 ± 13.2	0.67
Triglycerides (mg/dl)	135.0 ± 77.4	135.6 ± 78.4	0.31
Glucose lowering drugs			
Metformin (%)	69.5	67.9	<0.0001
Sulphonylureas (%)	13.3	12.6	0.01
Glinides (%)	2.2	2.0	0.13
Pioglitazone (%)	4.0	4.0	0.88
Acarbose (%)	2.3	2.1	0.05
DPP4i (%)	24.8	24.5	0.40
GLP1-RA (%)	10.9	12.0	<0.0001
SGLT2i (%)	12.3	13.2	0.001
Basal insulin (%)	28.1	28.5	0.39
Short acting insulin (%)	18.9	19.4	0.07

Data are n (%) and mean ± SD.

represented an unprecedented challenge for health systems all over the world and it has undermined the continuity of care for people suffering from chronicity, such as those with diabetes. Because the health system was overwhelmed, most (if not all) routine follow-up appointments considered as non-emergencies were delayed or cancelled, and hospital access for patients with chronic conditions was hindered.

T2DM is one of the most diffused chronic conditions worldwide, affecting millions of people, and it is also one of the most prevalent comorbidities among subjects who have died from COVID-19 [16], together with hypertension [17].

During these challenging times, the diabetologists have acquired new technological and communication skills in order to be able to deal with patients despite all the known limitations and criticalities. Indeed, the presence of diabetes significantly worsens the prognosis of COVID-19 infected patients, increasing the incidence of adverse outcomes, including mortality [18–20].

In this context, telemedicine became a pivotal and undeniably useful tool for the management of distant patients; started in a hurry during the lock-down periods, and profusely adopted also at later times of social distancing. Most hospital contexts have simply activated telephone lines dedicated to telemedicine services, but the most advanced locations have also been able to take advantage of technological innovations, and exchanged electronic data automatically via email or "cloud", as advanced informatics tools can simplify the analysis and provide suggestions to guide the clinical decision of physicians.

Italian diabetologists have responded in a timely and effective manner to this emergency, making up for the lack of face-to-face visits by contacting stable patients remotely, and leaving the "in person" services open for urgent visits. Through the adoption of telemedicine, people with diabetes have been able to keep in touch with their care team, managing to meet their care needs even in a moment that was critical for every-one, but especially for frail patients, suffering from comorbidities.

The observations deriving from the evaluation of the AMD Annals fit perfectly into the narrative depicted by studies carried out in patients with diabetes in non-pandemic situations, showing remote interventions are well received and have the potential to improve glycaemic control [21,22].

Notably, our data also show that the selection of patients destined to the telemedicine approach did not follow any guidelines, but tried to favour older patients with T2DM and with better metabolic control, requiring less therapeutic changes. From our data, it emerges that patients with a good metabolic control and those who did not need to change their hypoglycaemic therapy were the most manageable from a distance. Frail patients were the category that benefited the most from telemedicine services: mainly elderly people with comorbidities and complications, more often women, assisted remotely in order to avoid exposing them to contagion. This observation is consistent with previous demonstrations that telemedicine is more effective than routine care at achieving glucose control in patients with long-standing diabetes, comorbidities and scarcely acquainted with informatics/digital technologies [21,22].

In our data set, patients on telemedicine were also more frequently women. Our study described quality of care as it is actually delivered in the overall population, irrespective of sex, since a previous evaluation from the same population already demonstrated a similar quality of diabetes care, including the Q-score values, in T2DM men and women participating to the AMD Annals Initiative [23].

Moreover, we noticed a higher prevalence of DPP4i use among patients assisted through telemedicine. According to our clinical experience, this phenomenon could be attributed to the higher presence of older subjects with reduced renal function [24], coupled with the fact that other novel approaches (such as SGLT2i and GLP1-RA) require a therapeutic plan and need to be fully explained to the patients.

The total prevalence of cardiovascular events and dialysis was superimposable in the two groups. Stroke was more frequent among those on telemedicine, and interestingly, subjects seen in presence had a higher prevalence of foot complications and more severe forms of retinopathy, from non-proliferative to laser therapy. The distribution of foot complications in the two groups may be a consequence of an indication bias, because T2DM subjects with foot complications required hands-on consultation. Similarly, patients with retinopathy might have been preferentially destined to face-to-face visits. In spite of this it should be remarked that, although the technology was not available for our studies, retinopathy has been demonstrated to be effectively manageable through telemedicine, thanks to the development of devices for remote evaluation of retinal digital photos, that can also be taken without inducing mydriasis, thus simplifying image acquisition, with very high diagnostic accuracy [25].

Our data have also been able to highlight the most important limitations of telemedicine, because the greatest difference observed was in the monitoring of complications and lab test results, which were penalized for patients followed at a distance. Indeed, monitoring of major cardiovascular risk factors as well as screenings for complications have been neglected, especially retinopathy and diabetic foot assessments, because of the suspension of non-urgent services and the commitment of diabetologists to COVID-19-dedicated wards, causing important repercussions on the health of all people with diabetes. Although these data are linked to the specific difficulties in accessing cures during the COVID-19 pandemic [26], they represent an alarm bell for the future implementation of structured telemedicine programs, which should take into account the significant reduction in monitoring HbA1c and other major risk factors for long-term complications such as cardiovascular disease [27]. Although the intervention did not yield short-term benefit for the participants in terms of complications, it is notable that it also was not associated with worse outcomes. Nevertheless, we should keep in mind that AMD Annals' data were analysed cross-sectional, and as such we have no notion of the impact that the clinical practices implemented during the emergency period may have on future development and progression of complications. Finally, it should be reminded that that telemedicine not always represents the optimal choice, neither for patients, nor for physicians. Special situations, in particular acute conditions, require face-to-face consultation or immediate hospitalization, and cannot be confronted by telemedicine. Furthermore, some patients would prefer to meet up with their physicians in person, and not to communicate on a screen, and cultural or emotional barriers could interfere with a telemedicine approach; moreover, a proper physical examination of the patient is of course impossible [28].

Overall, telemedicine has the potential to become a practical and time-sparing option, for patients, caregivers and physicians, when physical proximity is not fundamental. This innovative approach, if applied with intelligence and mindfulness, can improve the management of diabetes in a clinically relevant manner, and reduce fearsome clinical outcomes. Our data indicate that there are no limitations of age or clinical conditions for patients to be addressed to the telemedicine approach, since also old, frail patients have been demonstrated to have benefits when consulted at a distance.

The challenge facing the National Health Service is to ensure that telemedicine becomes a structured, optimized and well-coded path of care, capable of fully inserting itself as a complementary/hybrid assistance modality for the management of people with diabetes.

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6. Authorship

All authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and that it will not be published elsewhere in the same form, in English or in any other language, including electronically, and have given their approval for this version to be published.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.diabres.2022.110158.

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