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ORIGINAL ARTICLE

Screening for diabetic retinopathy with different levels of financial incentive in a randomized controlled trial

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ABSTRACT

Aims/Introduction: To examine the impact of different levels of financial incentive in terms of fee subsidization on diabetic retinopathy screening in the private primary care setting in Hong Kong.

Materials and Methods: All general practitioners working in the private sector and registered in two electronic public databases were invited to participate. Consecutive patients with diabetes mellitus were then recruited by the participating practitioners. The recruited participants were randomly allocated to one of three screening groups with different fee levels (HK$0, HK$150 [US$19], HK$300 [US$39]) in a randomized controlled trial. Screening uptake and severity of diabetic retinopathy detected were compared.

Results: Out of 1,688 eligible practitioners, 105 participated and invited 402 patients, with 239 initially agreeing to participate (59.5%). After randomization, 78, 75 and 76 participants in the HK$0, HK$150 and HK$300 fee groups, respectively, reconfirmed their participation and were offered screening at the relevant fee. The uptake of screening was 79.5% (62/78), 81.3% (61/75) and 63.2% (48/76), in the HK$0, HK$150 and HK$300 groups, respectively ($P < 0.018$). Being in the HK$150 fee group was associated with higher uptake of screening than being in the HK$300 fee group (odds ratio 2.31, $P = 0.039$). No significant difference was found in the prevalence of any diabetic retinopathy (33.9%, 27.9% and 37.5%, $P = 0.378$) or sight-threatening diabetic retinopathy (4.8%, 8.2% and 16.7%; $P = 0.092$) among the groups.

Conclusion: A screening fee of HK$150, representing approximately a half subsidy, appears to be as effective in maximizing uptake as a full subsidy (HK$0) and without deterring those at high risk of diabetic retinopathy from screening.

INTRODUCTION

Diabetic retinopathy (DR) is a complication of diabetes mellitus and one of the most common causes of avoidable blindness[1–4]. The prevalence of DR increases with the duration of diabetes and with other risk factors, such as high blood glucose and high blood pressure. Timely treatment, such as laser photocoagulation[5] and intravitreal antivascular endothelial growth factors[6], reduces the incidence of visual loss, and screening for DR is one of the most cost-effective forms of providing healthcare[7,8].

Free, systematic screening for DR was introduced in the UK during 2003–2008[9]. This fulfils the concept of making effective, preventive care free of charge, as suggested by Dr Julian Tudor Hart in 1971,[10] and was supported by our earlier findings that even a small fee discouraged a higher risk group from attending DR screening in Hong Kong[11]. However, the UK National Health Service system is not the norm in many countries, including Hong Kong, where full fees for service and co-payments are common for primary and preventive care services.

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While contributing to financial sustainability, the fees might impose a financial barrier, especially for low-income groups[12,13]. Whether a financial incentive or subsidy would improve uptake of preventive care, and to what extent, is an important question and might vary for different conditions. One study using varying levels of cash incentive on return for tuberculosis skin test reading found that the returning rate increased with the increasing amount of the incentive[14], whereas a meta-analysis on the effect of financial incentives in weight reduction programs failed to find any statistically significant effect on weight loss or long-term maintenance[15]. Varying subsidies on the cost of nicotine gum showed increased uptake with a higher subsidy, but a non-significant trend of impact on smoking cessation[16].

Hong Kong has a mixed public and private healthcare system, with the public primary care services being used mainly by the elderly and lower income members of society. Although only a small co-payment is charged for public services, many still choose the private sector for their primary care due to its greater flexibility (appointment time and location, choice of doctors), and for which they normally pay full fees, unless insured. Our previous randomized controlled trial in a public primary care clinic showed that eliminating the co-payment of HK$60 (US$7.8) significantly improved the uptake of DR screening[11]. Furthermore, a higher rate of DR was found in the 'free' group, indicating that individuals at higher risk of disease had been deterred from screening in the group with a co-payment. These findings were not fully explained by socioeconomic factors, but were in line with the predictions of Tudor Hart's Inverse Care Law[10] that those in greatest need are least able to access care, particularly when market factors are involved.

In the mixed public and private healthcare system of Hong Kong, approximately 10% of those with diabetes mellitus receive their care in the private sector[17]. These people would normally need to pay the full market cost of DR screening in the private sector. Providing a financial incentive in terms of a fee subsidy might support the uptake of DR screening, and encourage primary care to be continued, in the private sector. This will also help avoid inundating the heavily subsidized public sector with the less needy, and allow more resources to be allocated to the underprivileged. Therefore, we wished to test the impact of a financial incentive in the form of a fee subsidy on the uptake of DR screening in the private sector, and examine whether a higher financial incentive would encourage a higher uptake of screening.

MATERIALS AND METHODS

Study design

A randomized control trial was carried out in which screening was offered at three different fee levels (HK$0, HK$150 or HK $300) with random allocation of the fee to each participant; the screening, which was free of charge (HK$0), would enable assessment of likely maximum uptake with minimal financial barrier. The screening at the other two fee levels would enable assessment of uptake with half subsidy (HK$150, equivalent to US$19) and a more sustainable market price (HK$300, full cost-recovery equivalent to US$39).

The participants were recruited through their own general practitioners (GPs) in the private sector, who were registered in two territory-wide, public databases: the Hong Kong Primary Care Directory and the eHealth System. All registered GPs were invited to participate through an invitation letter (along with a study summary pamphlet) mailed to their clinic, with a follow-up reminder by fax and phone calls (an average of five calls were made at different times of the day to increase the chance of successful contact). Further information and data collection forms were mailed to GPs who agreed to participate, and a researcher further explained the process in person or by telephone.

When patients with diabetes mellitus attended the participating clinic, they were invited to take part in the study by their GP who, if their patient agreed, would forward the contact details and clinical information to the research team. Each participant was randomly allocated to one of the screening fee groups, HK$0, HK$150 or HK$300, using block randomization with a block size of three. The research team generated a random number for each participant recruited in each week and re-ordered them from the lowest to highest values of the random numbers. After the order sequence, participants were grouped into blocks, with each of the participants in the block being randomly assigned one of the three fee levels (HK$0, HK $150 or HK$300). A structured interview was carried out by telephone and the participant was invited to a DR screening session with the randomly allocated fee level. If they accepted, a screening appointment was made at their choice of site among three across Hong Kong.

Screening and grading for DR followed the same standard procedure as used in the public screening system[18]. Visual acuity and retinal photographs of each participant were obtained at the screening session by qualified optometrists, and then graded by primary and secondary graders (trained optometrists), with arbitration grading by an experienced ophthalmologist, when required. The possible gradings were: no DR (R0), background DR (R1), pre-proliferative DR (R2), proliferative DR (R3), no diabetic maculopathy (M0), diabetic maculopathy (M1), ungradable (U), no signs of previous photocoagulation (P0) and signs of previous photocoagulation seen (P1)[18].

All graders were blinded to the participants' screening fee level. Sight-threatening diabetic retinopathy (STDR) was defined as one or more of R2, R3, M1 or P1, and required follow up by an ophthalmologist. The DR screening report with grading results and clinical recommendations was sent back to each participant's GP. The study flowchart is shown in Figure 1.

The sample size was based on the ability to detect a significant difference in the uptake of screening. To detect a difference of 20% (considered of clinical significance) in uptake between groups, with an alpha error of 5% and power of 80%,

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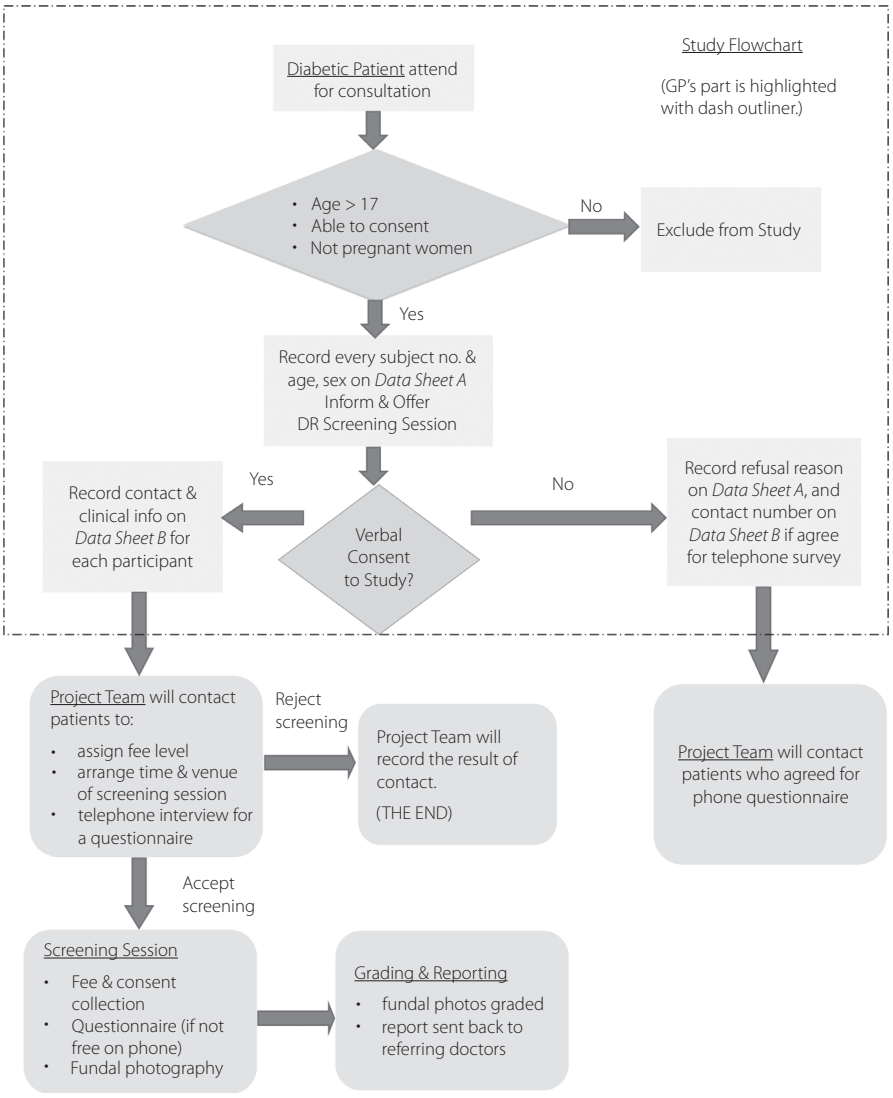

Figure 1 | Flowchart of study procedure.

the sample size required was a minimum of 82 participants. Allowing for an 80% participation rate, we aimed for 103 in each group and terminated recruitment after 402 participants had been approached. G-power was used for the sample size calculation.

Data collection

The questionnaire for the telephone survey included details of current care for diabetes, any past DR screening, history of ocular and systemic diseases, self-perceived health, lifestyle, awareness of DR, willingness to pay for screening, demographic information and acceptability of screening at the assigned fee level. All questions had been validated in previous studies[11,19]. Data supplied by the GP included the date of birth, diabetes mellitus type and duration, latest glycated hemoglobin (HbA1c), and blood pressure measurements as principal risk factors for DR.

Statistical analysis

The characteristics of participants in the three groups were compared using ANOVA for continuous variables, and the χ^2-test for categorical variables. The hypothesis that a higher subsidy would result in a higher screening uptake rate was tested by comparing the three groups, with uptake defined as the number of participants who presented for screening divided by the number who completed the questionnaire. The 95% confidence interval for the difference in the uptake rate between the groups was calculated based on the Wilson score intervals[20,21]. A continuity correction was applied to approximate the binomial distribution with a normal distribution. The number identified

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with any DR or STDR at screening was also compared between groups.

Differences in characteristics between those screened and not screened in each group were compared using the questionnaire and data supplied by the GP. Univariate and multivariate logistic regression models were used to identify factors associated with screening uptake among the groups, and the fee level was included as an independent variable. The model was further adjusted for age, sex and family income level. Other potential factors tested in the univariate analysis included awareness of DR, self-perceived health, smoking status and clinical factors (duration of diabetes mellitus, HbA1c, systolic and diastolic blood pressure). Any factor significant ($P < 0.05$) in the univariate analysis was also entered into the multivariate logistic regression model, and the association between screening uptake and independent variables was reported as odds ratios (ORs) with P-value <0.05 considered as statistically significant.

Ethics approval was obtained from the institutional review board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB; Ref: UW 14-584), and the Research Ethics Committee (Kowloon Central/Kowloon East; REC[KC/KE]; Ref: KC/KE-16-0064). The clinical trial is registered with the US National Institutes of Health Protocol Registration System (NCT02866734, available at: https://www.clinicaltrials.gov/ct2/show/NCT02866734?cond=Diabetic+Retinopathy&cntry=HK&rank=1). All participants gave informed consent before taking part, and the research adhered to the tenets of the Declaration of Helsinki.

RESULTS

Private GP recruitment

The invitation letter was sent to 1,688 GPs in the private sector, of whom, 838 (49.6%, 838/1,688) replied. From those GPs who replied, 105 (12.5%, 105/838) agreed to participate and recruit participants for the study. The top three reasons for refusal to participate were 'not interested' (25.2%, 185/733), 'very few diabetes mellitus patients' (18.0%, 132/733) and 'too busy' (16.2%, 119/733).

Participant recruitment and uptake rate of screening

Of the 402 eligible patients who were invited by their GP, 239 (59.5%, 239/402) agreed to participate. Major reasons for declining to participate were being already under the care of an ophthalmologist or enrolled in a public DR screening program (71.2%, 116/163). Participant recruitment was carried out between September 2016 and November 2017.

The participants were randomized to fee groups of HK$0 ($n = 79$), HK$150 ($n = 80$) or HK$300 ($n = 80$). Completeness of clinical data was 100% for sex and age, 99.6% (238/239) for duration of diabetes mellitus, 77.0% (184/239) for HbA1c, and 97.1% (232/239) for blood pressure measurements. Four participants repeatedly failed to answer calls, and six withdrew without completing the questionnaire and before they were notified of the random fee level (Figure 2). This left 78 (out of 79) in the HK$0 fee group, 75 (out of 80) in the HK$150 group and 76 (out of 80) in the HK$300 group. There were no differences in characteristics among the groups (Table 1).

Of the 78 in the HK$0 fee group who were informed of their assigned fee, 62 (79.5%) attended screening, as did 61 of 75 (81.3%) in the HK$150 fee group and 48 of 76 (63.2%) in the HK$300 fee group ($P < 0.018$). Compared with the HK$300 group, both the HK$0 group (79.5% vs 63.2%, $P = 0.025$) and the HK$150 group (81.3% vs 63.2%, $P = 0.013$) had significantly higher uptake of screening with an absolute difference of 16.3% (95% confidence interval with continuity correction 1.1–30.7%) and 18.2% (95% confidence interval with continuity correction: 2.9–32.4%) respectively. The uptake rate did not differ between the HK$0 and HK150 group (79.5% vs 81.3%, $P = 0.774$).

Factors associated with uptake of screening

After adjustment for age, sex, monthly family income and other significant variables, a screening fee of HK$150 was still significantly associated with a higher uptake of screening (OR 2.31, $P = 0.039$) compared with a fee level of HK$300 (Table 2). There was a non-significant trend of higher uptake for HK$0 (OR 1.90, $P = 0.103$) compared with HK$300. Male sex (OR 2.28, $P = 0.015$), higher family income (HK$30,000 or above, OR 3.16, $P = 0.027$) and a belief that DR screening is important (OR 3.46, $P = 0.011$) were positively associated with uptake of screening.

Findings on the extent of DR

The prevalence of any DR was not significantly different between the groups: 33.9% (21/62) in the HK$0 fee group, 27.9% (17/61) in the HK$150 fee group and 37.5% (18/48) in the HK$300 fee group ($P = 0.378$; Table 3), whereas the prevalence of STDR was 4.8% (3/62), 8.2% (5/61) and 16.7% (8/48), respectively, ($P = 0.092$). Although not significantly different among the groups, the prevalence of any DR and STDR were both higher in the HK$300 fee group than the other two fee groups. Further data exploration showed that there were larger differences in the HbAc1 values (7.9% vs 7.2%) between the screened and non-screened participants in the HK$300 group than in the other two groups (7.9% vs 8.0% in HK$150; 7.8% vs 7.5% in the HK$0 group), although this difference was not statistically significant (Table 4).

No harmful or unintended effects were observed in any group during the study.

DISCUSSION

The present study aimed to determine the impact of different fee levels on DR screening for individuals with diabetes in the private sector. We found that providing a half subsidized service at HK$150 significantly improved uptake compared with charging the full cost-recovery fee of HK$300 (81.3% vs 63.2%, $P = 0.013$). Further increasing the subsidy and eliminating the user fee altogether did not improve uptake further (81.3% vs 79.5%, $P = 0.774$). This suggests that a half subsidy of the

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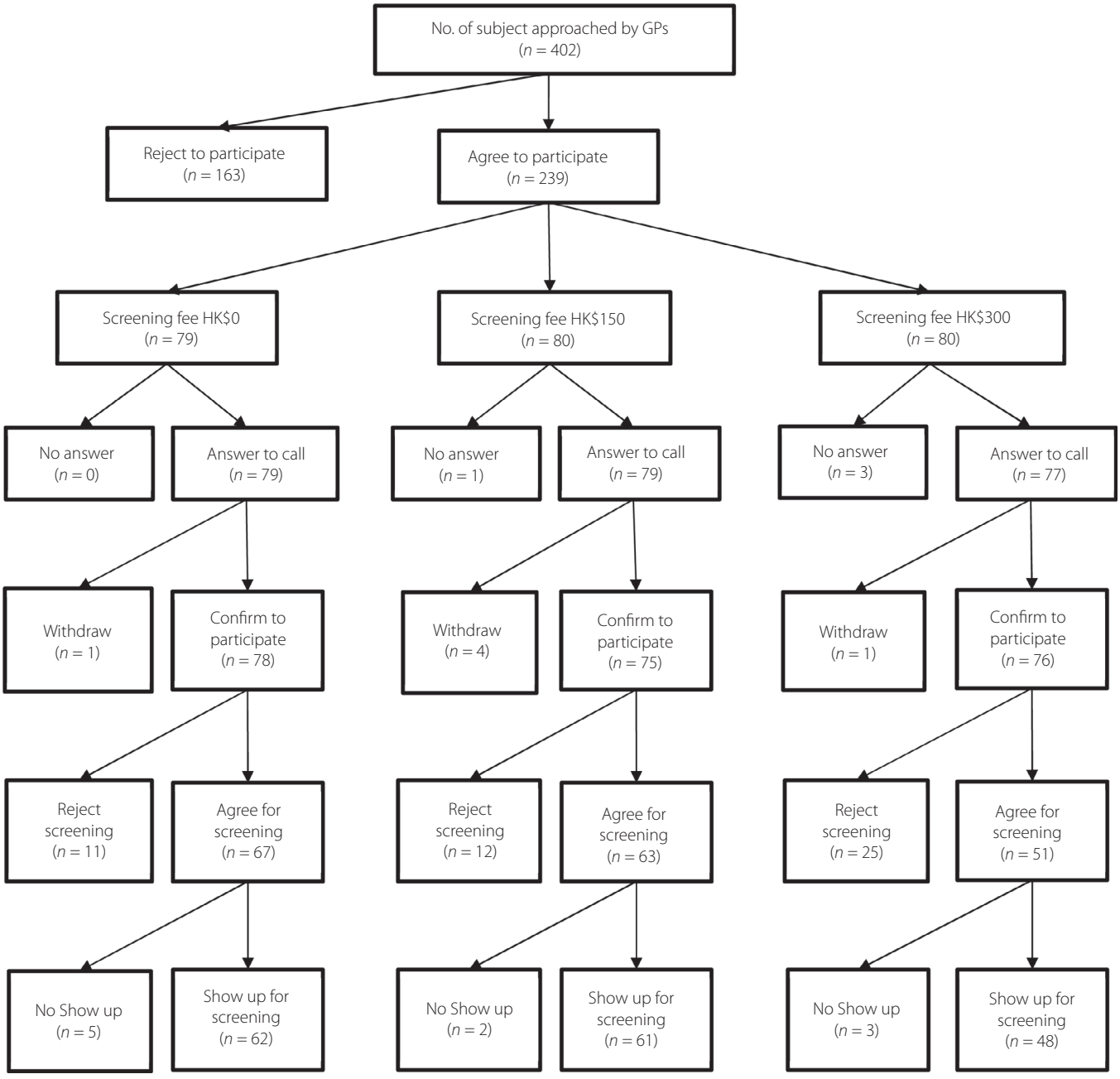

Figure 2 | Patient recruitment flow.

screening fee is likely to be sufficient incentive to encourage uptake of DR screening in the private sector in Hong Kong.

Although the prevalence of any DR and STDR at screening did not differ significantly among the three groups, there was a consistently higher level of both in the highest fee group, being 37.5% for any DR (compared with 27.9% for HK$150 and 33.9% for HK$0) and 16.7% for STDR (being 8.2% for HK150 and 4.8% for HK$0). Further analyses implied some possible deterrent effect of a higher fee on lower-risk individuals (lower HbA1c levels), but charging the full fee of HK$300 does not appear to have equally deterred the higher risk individuals. This is contrary to our finding in the public primary care setting[11], where a relatively low co-payment of $HK60 apparently reduced the uptake (82.4% vs 88.5%, $P < 0.001$) of screening. However, those who attended for screening at HK$60 had a lower prevalence of DR at screening (20.3% vs 25.9%, $P = 0.004$) than those who attended screening with no co-payment. This implies that charging even a low fee in the public

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Table 1 | Characteristics of confirmed participants by group

	Overall (n = 229)	Fee group \$0 (n = 78)	Fee group \$150 (n = 75)	Fee group \$300 (n = 76)	P-value
Sex, male/female (%)	141/88 (62%/38%)	52/26 (67%/33%)	43/32 (57%/43%)	46/30 (61%/39%)	0.482†
Mean age (SD)	59.8 (11.3)	58.2 (10.4)	59.1 (11.7)	62.1 (11.5)	0.080‡
Marital status, n (%)					
Never married	30 (13.1)	11 (14.1)	12 (16.0)	7 (9.2)	0.583†
Married	166 (72.5)	58 (74.4)	50 (66.7)	58 (76.3)	
Separated/divorced/widowed	33 (14.4)	9 (11.5)	13 (17.3)	11 (14.5)	
Education level, n (%)					
Primary or below	58 (25.3)	20 (25.6)	17 (22.7)	21 (27.6)	0.844†
Secondary (F.1–6)	104 (45.4)	34 (43.6)	37 (49.3)	33 (43.4)	
Post-secondary or above	66 (28.8)	23 (29.5)	21 (28.0)	22 (29.0)	
Refuse to answer	1 (0.4)	1 (1.3)	0 (0)	0 (0)	
Monthly family income (HK\$), n (%)					
<\$10,000 (including no income)	68 (29.7)	16 (20.5)	19 (25.3)	33 (43.4)	0.058†
\$10,000–19,999	41 (17.9)	15 (19.2)	18 (24.0)	8 (10.5)	
\$20,000–29,999	39 (17.0)	13 (16.7)	15 (20.0)	11 (14.5)	
\$30,000–39,999	21 (9.2)	7 (9.0)	9 (12.0)	5 (6.6)	
≥\$40,000	46 (20.1)	20 (25.6)	12 (16.0)	14 (18.4)	
Refuse to answer/don't know	14 (6.1)	7 (9.0)	2 (2.7)	5 (6.6)	
Occupation, n (%)					
Retired	80 (34.9)	25 (32.1)	22 (29.3)	33 (43.4)	0.364†
Home maker	13 (5.7)	4 (5.1)	4 (5.3)	5 (6.6)	
Employed	136 (59.4)	49 (62.8)	49 (65.3)	38 (50.0)	
Smoking status, n (%)					
Non-smoker	151 (65.9)	44 (56.4)	56 (74.7)	51 (67.1)	0.198†
Current smoker	28 (12.2)	13 (16.7)	7 (9.3)	8 (10.5)	
Ex-smoker	50 (21.8)	21 (26.9)	12 (16.0)	17 (22.4)	
Diabetes type, n (%)					
Type 1	3 (1.3)	1 (1.3)	1 (1.3)	1 (1.3)	1.000§
Type 2	226 (98.7)	77 (98.7)	74 (98.7)	75 (98.7)	
Duration of diabetes (n)	229	78	75	76	
Mean, years (SD)	7.0 (6.3)	6.3 (5.3)	6.8 (6.5)	7.8 (7.1)	0.308‡
HbA1c (n)	177	60	57	60	
Mean, % (SD)	7.8 (2.2)	7.7 (2.4)	7.9 (2.4)	7.6 (1.7)	0.725‡
Systolic BP (n)	222	77	72	73	
Mean, mmHg (SD)	129.5 (15.7)	129.8 (13.1)	129.3 (15.5)	129.3 (18.3)	0.971‡
Diastolic BP (n)	222	77	72	73	
Mean, mmHg (SD)	77.3 (9.7)	78.1 (9.5)	77.5 (9.1)	76.2 (10.4)	0.448‡
Awareness of DR					
Know diabetes could affect blindness, n (%)					
No	7 (3.1)	1 (1.3)	2 (2.7)	4 (5.3)	0.677†
Yes	199 (86.9)	70 (89.7)	65 (86.7)	64 (84.2)	
Don't know	23 (10.0)	7 (9.0)	8 (10.7)	8 (10.5)	
Think DR screening is important, n (%)					
No	19 (8.3)	5 (6.4)	5 (6.7)	9 (11.8)	0.697†
Yes	205 (89.5)	71 (91.0)	68 (90.7)	66 (86.8)	
Don't know	5 (2.2)	2 (2.6)	2 (2.7)	1 (1.3)	
Perceived frequency of screening, n (%)					
Never	3 (1.3)	1 (1.3)	0 (0)	2 (2.6)	0.313†
Less often	22 (9.6)	7 (9.0)	6 (8.0)	9 (11.8)	
Every 6 months	56 (24.5)	17 (21.8)	21 (28.0)	18 (23.7)	
Every year	109 (47.6)	44 (56.4)	36 (48.0)	29 (38.2)	
Don't know	39 (17.0)	9 (11.5)	12 (16.0)	18 (23.7)	

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Table 1 (*Continued*)

	Overall (*n* = 229)	Fee group $0 (*n* = 78)	Fee group $150 (*n* = 75)	Fee group $300 (*n* = 76)	*P*-value
Believe early diabetic retinopathy is symptomatic, *n* (%)					
No	110 (48.0)	36 (46.2)	37 (49.3)	37 (48.7)	0.877†
Yes	41 (17.9)	12 (15.4)	14 (18.7)	15 (19.7)	
Don't know	78 (34.1)	30 (38.5)	24 (32.0)	24 (31.6)	
Aware there is treatment available for diabetic retinopathy, *n* (%)					
No	157 (68.6)	54 (69.2)	56 (74.7)	47 (61.8)	0.234†
Yes	72 (31.4)	24 (30.8)	19 (25.3)	29 (38.2)	

BP, blood pressure; DR, diabetic retinopathy. †χ^2-test. ‡One-way ANOVA test. §Fisher's exact test.

Table 2 | Multivariate logistic regression analysis on factors associated with uptake of screening

	Odds ratio	95% CI	*P*-value
Fee level			
$300	1.00		
$150	2.34	1.06–5.18	0.036
$0	1.91	0.88–4.15	0.100
Age (years)	1.02	0.98–1.05	0.408
Sex			
Female	1.00		
Male	2.25	1.16–4.36	0.016
Monthly family income (HK$)			
<$10,000 (including no income)	1.00		
$10,000–29,999	2.30	0.91–5.80	0.078
≥$30,000	3.16	1.14–8.76	0.027
Refuse to answer/don't know	1.26	0.34–4.66	0.727
Think DR screening is important			
No/don't know	1.00		
Yes	3.36	1.30–8.68	0.012

Total *n* = 229. CI, confidence interval; DR, diabetic retinopathy.

sector deterred those at higher risk. In contrast, a higher fee did not deter those at higher risk in the present study carried out in the private sector, and in fact, we actually had more higher-risk attendees for the highest fee level, as shown by their HbA1c levels and screening outcomes. This difference between public and private sectors might be partly due to the patient's ability to pay, as almost half (46.3%) of the patients in the private sector had a monthly family income ≥HK$20,000, compared with just 12.0% in the public sector.

Another reason for the difference might be health awareness, with a greater understanding of their risk for DR, which could be higher among our participants in the private sector. This could lead to a higher willingness to pay for screening. Another factor might be encouragement by the GP to accept the screening, although we tried to encourage all GPs to make the same type of approach to all patients. However, a GP concerned about their patient's risk might convey that concern non-verbally.

It has been suggested that higher incentives would have more impact than lower incentives[22]. However, the present results

Table 3 | Findings on diabetic retinopathy

	Overall (n = 171)	Fee group $0 (*n* = 62)	Fee group $150 (*n* = 61)	Fee group $300 (*n* = 48)	*P*-value
Retinopathy, *n* (%)					
R0	112 (65.5)	42 (67.7)	41 (67.2)	29 (60.4)	0.190†
R1	43 (25.2)	19 (30.7)	12 (19.7)	12 (25.0)	
R2	11 (6.4)	1 (1.6)	5 (8.2)	5 (10.4)	
R3	1 (0.6)	0 (0)	0 (0)	1 (2.1)	
Ungradable	4 (2.3)	0 (0)	3 (4.9)	1 (2.1)	
Maculopathy, *n* (%)					
M0	159 (93.0)	61 (98.4)	57 (93.4)	41 (85.4)	0.015†
M1	8 (4.7)	1 (1.6)	1 (1.6)	6 (12.5)	
Ungradable	4 (2.3)	0 (0)	3 (4.9)	1 (2.1)	
Previous laser therapy, *n* (%)					
P0 (no)	166 (97.1)	61 (98.4)	58 (95.1)	47 (97.9)	0.288†
P1 (yes)	1 (0.6)	1 (1.6)	0 (0)	0 (0)	
Ungradable	4 (2.3)	0 (0)	3 (4.9)	1 (2.1)	
Any DR, *n* (%)	56 (32.7)	21 (33.9)	17 (27.9)	18 (37.5)	0.378†
STDR‡, *n* (%)	16 (9.4)	3 (4.8)	5 (8.2)	8 (16.7)	0.092†
Ungradable, *n* (%)	4 (2.3)	0 (0)	3 (4.9)	1 (2.1)	

DR, diabetic retinopathy; STDR, sight-threatening diabetic retinopathy. †χ^2-test. ‡Graded as R2, R3, M or have previous treated proliferative retinopathy.

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Table 4 | Clinical characteristics of people screened and not screened by group

	Fee group $0			Fee group $150			Fee group $300		
	Rejected/no show (n = 16)	Attended screening (n = 62)	P-value	Rejected/no show (n = 14)	Attended screening (n = 61)	P-value	Rejected/no show (n = 28)	Attended screening (n = 48)	P-value
Sex, male/female (%)	8/8 (50%/50%)	44/18 (71%/29%)	0.113†	7/7 (50%/50%)	36/25 (59%/41%)	0.538†	12/16 (43%/57%)	34/14 (71%/29%)	0.016†
Mean age, years (SD)	60.2 (7.9)	57.6 (11.0)	0.388‡	58.6 (10.3)	59.1 (12.0)	0.885‡	65.0 (13.3)	60.4 (10.1)	0.092‡
Marital status, *n* (%)									
Never married	2 (12.5)	9 (14.5)	0.721†	4 (28.6)	8 (13.1)	0.253†	2 (7.1)	5 (10.4)	0.401†
Married	13 (81.3)	45 (72.6)		9 (64.3)	41 (67.2)		20 (71.4)	38 (79.2)	
Separated/divorced/widowed	1 (6.3)	8 (12.9)		1 (7.1)	12 (19.7)		6 (21.4)	5 (10.4)	
Education level, *n* (%)									
Primary or below	4 (25.0)	16 (25.8)	0.260†	3 (21.4)	14 (23.0)	0.770†	7 (25.0)	14 (29.2)	0.902†
Secondary (F.1–6)	7 (43.8)	27 (43.6)		6 (42.9)	31 (50.8)		13 (46.4)	20 (41.7)	
Post-secondary or above	4 (25.0)	19 (30.7)		5 (35.7)	16 (26.2)		8 (28.6)	14 (29.2)	
Refuse to answer	1 (6.3)	0 (0)		0 (0)	0 (0)		0 (0)	0 (0)	
Monthly family income (HK$), *n* (%)									
<$10,000 (including no income)	4 (25.0)	12 (19.4)	0.561†	7 (50.0)	12 (19.7)	0.088†	16 (57.1)	17 (35.4)	0.491†
$10,000–19,999	3 (18.8)	12 (19.4)		1 (7.1)	17 (27.9)		3 (10.7)	5 (10.4)	
$20,000–29,999	3 (18.8)	10 (16.1)		3 (21.4)	12 (19.7)		3 (10.7)	8 (16.7)	
$30,000–39,999	1 (6.3)	6 (9.7)		0 (0)	9 (14.8)		2 (7.1)	3 (6.3)	
≥$40,000	2 (12.5)	18 (29.0)		2 (14.3)	10 (16.4)		3 (10.7)	11 (22.9)	
Refuse to answer/don't know	3 (18.8)	4 (6.5)		1 (7.1)	1 (1.6)		1 (3.6)	4 (8.3)	
Occupation, *n* (%)									
Retired	5 (31.3)	20 (32.3)	0.321†	4 (28.6)	18 (29.5)	0.946†	17 (60.7)	16 (33.3)	0.065†
Home maker	2 (12.5)	2 (3.2)		1 (7.1)	3 (4.9)		1 (3.6)	4 (8.3)	
Employed	9 (56.3)	40 (64.5)		9 (64.3)	40 (65.6)		10 (35.7)	28 (58.3)	
Smoking status, *n* (%)									
Non-smoker	8 (50.0)	36 (58.1)	0.167†	10 (71.4)	46 (75.4)	0.168†	20 (71.4)	31 (64.6)	0.768†
Current smoker	1 (6.3)	12 (19.4)		3 (21.4)	4 (6.6)		3 (10.7)	5 (10.4)	
Ex-smoker	7 (43.8)	14 (22.6)		1 (7.1)	11 (18.0)		5 (17.9)	12 (25.0)	
Diabetes type, *n* (%)									
Type 1	0 (0)	1 (1.6)	1.000§	1 (7.1)	0 (0)	0.187§	0 (0)	1 (2.1)	1.000§
Type 2	16 (100)	61 (98.4)		13 (92.9)	61 (100)		28 (100)	47 (97.9)	
Duration of diabetes, years (*n*)	16	62		14	61		28	48	
Mean, years (SD)	6.2 (6.2)	6.3 (5.1)	0.971‡	8.2 (9.8)	6.5 (5.5)	0.378‡	7.1 (7.6)	8.2 (6.9)	0.532‡
HbA1c (*n*)	14	46		10	47		23	37	
Mean, % (SD)	7.5 (1.8)	7.8 (2.5)	0.736‡	8.0 (2.6)	7.9 (2.4)	0.988‡	7.2 (1.0)	7.9 (2.0)	0.130‡
Systolic BP (*n*)	16	61		12	60		27	46	
Mean, mmHg (SD)	130.4 (12.4)	129.7 (13.4)	0.853‡	129.6 (19.1)	129.2 (14.9)	0.944‡	134.9 (20.5)	126.0 (16.2)	0.045‡
Diastolic BP (*n*)	16	61		12	60		27	46	
Mean, mmHg (SD)	78.3 (9.4)	78.1 (9.6)	0.955‡	76.3 (8.6)	77.8 (9.3)	0.624‡	76.4 (9.9)	76.0 (10.7)	0.879‡

BP, blood pressure. †χ^2-test. ‡t-test. §Fisher's exact test.

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suggest that halving the fee for screening had as good an impact as no fee at all in the private sector. In this case, there was no dose response between the level of financial incentive and response in terms of healthcare-seeking behavior.

Considering the impact on uptake and the fact that individuals who accepted screening at HK$300 would also accept HK$150, a screening fee of HK$150 (half-subsidization) should be a good compromise between financial sustainability and maximizing uptake of a screening strategy in the private sector, which has already been shown to be a cost-effective option in the public sector[23]. The next step would be a full cost-effectiveness study of this screening strategy in the private sector with a 50% public subsidy, to avoid costs that might, further down the line, be shifted to the public sector as the person ages.

For now, using this first-pass effect, because it is likely that many of these individuals had not been screened for some time, if ever, we can consider the cost-effectiveness of this single screening event. Using the prevalence of DR from the group with the screening fee of HK$150, the cost per positive DR case detected was HK$538 (61 × 150/17), and the cost per positive STDR case detected was HK$1,830 (61 × 150/5) in government subsidies. To this would be added the costs of treatment for STDR and follow up of all the positive cases, but this would be set against the likely reduction in visual loss for these individuals. In Hong Kong, approximately 400,000 patients with diabetes are cared for by the Hospital Authority (public sector), which is estimated to account for approximately 90% of patients with known diabetes[17]. In other words, approximately 10% patients with known diabetes are in the private sectors with an estimated number of approximately 44,000. Up to 95% of the visual loss from DR could be prevented through early detection and timely treatment[18,19], DR screening is recognized as an essential part of long-term management for diabetes. The cost to the government of a half subsidy would be HK$6.6 million (HK$150 × 44,000) annually if a fixed annual screening interval is used or could be below this amount if a tailored, risk-based screening interval is used; for example, a 2-year interval given to individuals at low risk of DR, a 6-month interval given to high risk and the rest with a 1-year screening interval. At a cost of only approximately HK$2,000 (US$256) per high-risk case (STDR) detected, such a program should result in a major reduction in visual loss due to DR and is likely to be cost-effective, even after including the cost of treatment and follow up. Adding the fact that the identification of DR can alert the GP to patients with higher cardiovascular and cerebrovascular risks, providing an opportunity for risk reducing interventions, there is a potentially large long-term saving to the public sector where many of these patients will seek care in later years.

One of the limitations of the present study was the potential for missing a few private GPs who were not registered with the two public registration databases we used. However, these are currently the most complete electronic lists of private GPs in Hong Kong. Those who obtain most of their primary healthcare in the private sector are still able to access DR screening in the public sector of Hong Kong, so the present participants will not represent the entire diabetes population in the private sector, but it is likely to represent that group who do not have access to DR screening from any other providers. A larger sample size would have enabled more precision of the effect, which we estimate to be approximately 18% higher uptake of screening with subsidy or between 3% and 32%. However, it is always difficult to recruit participants from the private sector services in Hong Kong.

The present study had a few strengths. It had an randomized controlled trial design, which enabled us to examine the impact of different fee levels on screening. We were able to measure not only the uptake of screening, but also the outcomes (any DR or STDR). The results should contribute to the literature on the impact of financial incentives on healthcare-seeking behavior, and will have implications for places where co-payments are common and where a financial incentive could encourage the uptake of preventive services.

In conclusion, if effective, quality-controlled screening for DR is to be established in the private primary care sector in Hong Kong; a screening fee of HK$150, representing approximately half subsidy by the government, will likely maximize uptake. This will contribute to the financial viability of the service and the continuity of primary care in the private sector. It also appears that this level of fee will not significantly deter those at higher risk of DR in the private sector.

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DISCLOSURE

The authors declare no conflict of interest.

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