

## **Health beliefs affect the correct replacement of daily disposable contact lenses: predicting compliance with the Health Belief Model and the Theory of Planned Behaviour.**

<sup>1</sup>Stefano Livi, PhD, D.Psych

<sup>2,3</sup>Fabrizio Zeri, PhD, Dip Optom (It), D.Psych, FIACLE, FBCLA.

<sup>3</sup>Rossella Baroni, D.Opt and Optom

<sup>1</sup> Department of Social and Developmental Psychology, University of Rome “Sapienza”.

<sup>2</sup> School of Life and Health Sciences, Aston University, Birmingham UK.

<sup>3</sup>Department of Sciences, Roma TRE University, Italy.

### **Correspondence**

Stefano Livi

Department of Social and Developmental Psychology, University of Rome “Sapienza”

Via dei Marsi, 78, 00185 Rome (Italy).

e-mail: stefano.livi@uniroma1.it

## Abstract

**Purpose:** To assess the compliance of Daily Disposable Contact Lenses (DDCLs) wearers with replacing lenses at a manufacturer-recommended replacement frequency. To evaluate the ability of two different Health Behavioural Theories (HBT), The Health Belief Model (HBM) and The Theory of Planned Behaviour (TPB), in predicting compliance.

**Method:** A multi-centre survey was conducted using a questionnaire completed anonymously by contact lens wearers during the purchase of DDCLs.

**Results:** Three hundred and fifty-four questionnaires were returned. The survey comprised 58.5% females and 41.5% males (mean age 34±12 years). Twenty-three percent of respondents were non-compliant with manufacturer-recommended replacement frequency (re-using DDCLs at least once). The main reason for re-using DDCLs was “to save money” (35%). Predictions of compliance behaviour (past behaviour or future intentions) on the basis of the two HBT was investigated through logistic regression analysis: both TPB factors (subjective norms and perceived behavioural control) were significant ( $p<0.01$ ); HBM was less predictive with only the severity (past behaviour and future intentions) and perceived benefit (only for past behaviour) as significant factors ( $p<0.05$ ).

**Conclusions:** Non-compliance with DDCLs replacement is widespread, affecting 1 out of 4 Italian wearers. Results from the TPB model show that the involvement of persons socially close to the wearers (subjective norms) and the improvement of the procedure of behavioural control of daily replacement (behavioural control) are of paramount importance in improving compliance. With reference to the HBM, it is important to warn DDCLs wearers of the severity of a contact-lens-related eye infection, and to underline the possibility of its prevention.

**Key Words:** Daily Disposable Contact Lenses, Compliance, Health Behavioural Theories, Health Belief Model, Theory of Planned Behaviour.

## 1. Introduction

Interest in compliance in the contact lens field has increased steadily since the 1980s. It was initially noted that ocular signs and symptoms during contact lens (CL) wearing were correlated with the level of wearer compliance [1], although this result is from the era of reusable and non-disposable lenses. Several subsequent studies have demonstrated that several non-compliant behaviours correlate with a higher risk of keratitis [2, 3, 4] and ocular inflammation [5].

One of the most studied non-compliant behaviours is the incorrect replacement rate of CL. There is a high level of non-compliance in following the manufacturer-recommended replacement frequency (MRRF) or the practitioner-recommended replacement frequency (PRRF) [6, 7, 8, 9, 10], with patients being less compliant with two-week CL than with one-month or daily disposable contact lenses (DDCLs) [6, 7, 8, 10].

Chalmers and colleagues found that DDCLs can lower the risk of corneal infiltrative events [11]. Reusing DDCLs can represent an important risk, as these wearers are less likely to receive proper training in cleaning and disinfecting lenses, and may not use a lens case or disinfecting solutions [12]. This may explain why, despite the possible benefits of DDCLs, some studies have found a similar risk of microbial keratitis in DDCLs and in other kinds of soft CLs [4].

The rate of non-compliant replacement of DDCLs varies from study to study. In 2007, Donshik and colleagues [6] found better compliance in following the recommended replacement schedule among DDCLs wearers compared to longer replacement contact lenses wearers. Nevertheless, the authors provide no clear estimation of the level of compliance.

In 2009 Dumbleton and colleagues [7] demonstrated that the non-compliance rate differs when the MRRF (15%) and the PRRF (12%) are considered. There are country-to-country variations in non-compliance rates: in the US, Yeung and colleagues [8] found a non-compliance rate of 14% in DDCLs wearers. A similar finding of 12% was seen by Dumbleton and colleagues in 2010 [13]. Canada's non-compliance rate was found to be 13% [14]. A more recent multi-country study found non-compliance rates of 18%, 12%, 7% and 4% in Australia, the US, the UK and Norway, respectively [15]. However, in two studies, non-compliance with MRRF for DDCL was much higher: 26% in the 2013 Dumbleton *et al.* study [10], and 30% in the 2011 Boost *et al.* study [12]. “*To save money*”, “*no risk in reusing*” and “*running out of lenses*” were the primary reasons given in some studies for reusing DDCLs [10, 15].

Over the past 40 years, many different models, known as Health Behaviour Theories (HBT), have been proposed to understand the determinants that can influence the likelihood of a certain health-related behaviour and possibly modify that behaviour accordingly. These include the Health Belief Model (HBM) [16] and the Theory of Planned Behaviour (TPB) [17, 18].

The HBM states that there are two main components affecting health-related behaviours: threat perception and behavioural evaluation. Threat perception includes two sub-components, perceived susceptibility and anticipated severity [19]. While perceived susceptibility refers to the extent an individual feels vulnerable to a health illness, anticipated severity refers to the perceived severity of the consequences of that illness. On the other hand, behavioural evaluation includes the potential benefit gained by engaging in a health behaviour (perceived benefit) and the perceived obstacles to enacting a health behaviour (perceived barriers) [20].

The TPB is a more general model that predicts behaviour from its immediate predictor, behavioural intentions. In turn, intention is determined by three main components: attitude, perceived behavioural control and subjective norms [17]. Attitude refers to a person's overall evaluation of a behaviour, perceived behavioural control refers to a person's perception of control in executing a behaviour and subjective norms refer to a person's beliefs about whether significant others (e.g. family members or peers) think he/she should engage in that behaviour [20, 21].

TPB has been applied to many health-related behaviours, such as exercise behaviour, oral hygiene behaviour, clinical or screening behaviour or HIV/AIDS health-related behaviour [21], but not to the study of compliance in the CL field. HBM has been applied to different health-related behavioural domains [22] and, in one study, HBM was used to study compliance in contact lens wearers [23]. To our knowledge, neither of the two models have been used to study incorrect replacement of CLs. Furthermore, HBM was never directly compared with the TPB in order to analyse their predictive powers for compliance. In fact, although both models have been shown to contain the most important psychological predictors of health-related behaviours, only a few studies have directly addressed the relative importance of these variables [19]. Although there are some recent studies in the DDCL literature that have demonstrated how attitudes toward CL affect wearers' intentions and behaviour [24, 25, 26, 27], there has been little work using HBT models in the CL domain.

Thus, the aim of this study is to assess the compliance of DDCL wearers, in terms of the frequency of replacement in line with MRRF in Italy, and to evaluate the ability of two

different health behaviour theories, namely the Health Belief Model and the Theory of Planned Behaviour, to predict past and future compliance.

## **2. Methods**

A multi-centre survey was conducted among different opticians in Italy. The study was conducted following the tenets of the Declaration of Helsinki. The opticians were initially invited, by mail, to participate in the study. They were chosen as representatives of different geographical areas (North, Centre and South) and city sizes (big cities, small cities), but also of different types of practice (independent, independent linked by buying syndicate, chains). However, as it was not possible to know how large the pool of DDCL purchases was over that time, the penetration rate could not be exactly estimated.

Every practice which agreed to participate in the study appointed a person to be in charge of collecting data. These employees were positioned at the front desk and instructed to hand the questionnaire to customers during the purchase of CLs. No compensation was given for participation. Participants were considered eligible for the survey if they had been DDCLs wearers for at least 6 months and if they were purchasing DDCLs, irrespective of the type. To avoid bias, the questionnaire was completed anonymously and without the CL practitioner being present. It was felt that this arrangement would be useful in preventing denial of non-compliant behaviour and so help in establishing the actual rate of non-compliance. The survey was conducted from October 2012 to January 2013.

The questionnaire included the following four sections:

-Demographic. This section included three questions evaluating gender, age and occupation.

-CL history of use and current wearing pattern. This section included four questions evaluating: number of years of previous CL use (up to 3 years, 4-6, 7-9, 10-12, more than 12); whether other types of non-DDCLs CLs were used (yes or no); number of days of wear per week; and number of hours of wear per day (up to 3 hours, 4-6, 7-9, 10-12, more than 12).

-Compliance, in terms of the extent of DDCL re-use. The first question evaluated if, in the previous month, the respondent re-used DDCLs: "In the last month did you use your CLs for more than one day?". The variable "Past compliance" was coded 1 for those who answered "No" (compliant behaviour) and 0 for "Yes" (non-compliant behaviour). Three further

questions were only asked to those who stated that they had re-used DDCLs regarding: how many times the interviewee re-used DDCLs; how many days on average the same DDCLs were used; and the main reason for re-use. Finally, future intentions to comply were measured by asking the participants how likely he/she was in the next month to replace the CLs every day (5 point Likert scale from 1 "definitely no" to 5 "definitely yes") (see Table 1).

-**TPB and HBM:** The final part of the questionnaire explored the two models studied in the research. For the former, we used a reduced-TPB model to keep the questionnaire short and simple enough for its specific setting (during CLs purchasing), and, for this reason, items on attitudes were eliminated. Subjective norms were explored by asking the interviewee whether the majority of people considered to be important by them would think it necessary to replace DDCLs every day. Perceived behavioural control was explored by asking if the interviewee perceived him/herself to be able to control the DDCLs everyday replacement. All items used a 5 point Likert scale ranging from 1 "definitely no/no control" to 5 "definitely yes/complete control" (see Table 1).

Finally, four questions explored the four dimensions of HBM framework following Efron's suggestions [23]: susceptibility (likelihood of a CL-related eye infection), severity (gravity of a CL-related eye infection), benefit perceived (possibility of preventing a CL-related eye infection), barriers perceived (complexity in preventing a CL-related eye infection). The interviewee's response was evaluated on a 5 point Likert scale from 1 "Not at all" to 5 "very much".

<b>Construct</b>	<b>Variable</b>	<b>Item</b>	<b>Response Scale</b>
Compliance in term of re-using DDCLs	<b>Past compliance</b>	<i>"In the last month did you use your CLs more than once?"</i>	Yes / No
	<b>Future intention to comply</b>	<i>"In the next month, how likely are you to replace the CLs every day?"</i>	from 1 "definitely no" to 5 "definitely yes"
<i>TPB</i>	<b>Subjective Norms</b>	<i>"Do the majority of people that are close to you think it is important to replace DDCLs every day?"</i>	1 "definitely no" to 5 "definitely yes"
	<b>Behavioural Control</b>	<i>"How much do you think you have the ability to control the DDCLs change every day?"</i>	from 1 "definitely no control" to 5 "complete control"

	<b>Susceptibility</b>	<i>"How likely do you think is you could develop an eye infection caused by the use of the DDCLs?"</i>	from 1 "Not at all" to 5 "very much"
	<b>Severity</b>	<i>"How severe do you think an eye infection caused by the use of DDCLs could be?"</i>	from 1 "Not at all" to 5 "very much"
HBM	<b>Benefit perceived</b>	<i>"How possible do you think it is to prevent a DDCL-related eye infection by following the correct procedure?"</i>	from 1 "Not at all" to 5 "very much"
	<b>Barriers perceived</b>	<i>"How complex do you think it is to prevent a DDCL-related eye infection?"</i>	from 1 "Not at all" to 5 "very much"

**Table 1:** Constructs and item used in the questionnaire.

Once an interviewee completed the questionnaire, he/she gave it to the front desk employee, who then had to seal the sheet in an envelope and write the details of the DDCLs purchased (e.g. optical power, number of DDCLs in package, manufacturer) in the correct space on the back.

### 3. Statistical analyses

In order to predict past compliance, a Logistic Regression Analysis was used to identify the relative significance of gender, age, kind of lens used (spherical vs. toric), mean spherical equivalent, manufacturer and the size of package bought. Logistic regression models were used to test the predictive power of the HBM and TPB variables for future intentions to comply, as well as past compliance. The analyses were run with listwise deletions of participants, that is, using only those participants who scored on all the variables included in the model. All statistical analysis was performed using SPSS 22.

### 4. Results

A total of 354 completed questionnaires were returned by 32 opticians out of 34 contacted. There were 166 questionnaires (47%) from 17 independent opticians linked by buying syndicate, 152 questionnaires (43%) from 12 independent opticians and 36 questionnaires

(10%) from 3 centres of chain opticians. The median number of questionnaires collected in each single centre was 9 (range 4-29).

The participant demographics and both the current wear pattern and the characteristic of CL worn are reported in Table 2 and Table 3, respectively.

#### Participant Demographics

Age (yrs)	33.8 ± 12 Range 12 to 73
Gender n (%)	Females, 204 (58%) Males, 145 (41%) No response, 5 (1%)
Occupation n (%)	Students, 95 (27%) Workers, 82 (23%) Other employments, 160 (45%) No response, 17 (5%)
Years in CL n (%)	Up to 3 years, 80 (23%) Between 4 and 6 years, 67 (19%) Between 7 and 9 years, 40 (11%) Between 10 and 12 years, 51 (14%) More than 12 years, 113 (32%) No response, 3 (1%)

**Table 2:** Participant Demographics

## CL current wear pattern and Lens type worn

Days of wear per week	$5.1 \pm 2$ (range 1-7)
Hours of wear per day, n (%)	Up to 3 hours 30 (8%) Between 4 and 6 hours 47 (13%) Between 7 and 9 hours 94 (27%) Between 10 and 12 hours 111 (31%) More than 12 hours 71 (20%) No response, 1 (0%)
Exclusive use of DDCLs, n (%)	Yes, only DDCLs were used, 249 (70%) No, also used other type of CLs 101 (29%) No response 4 (1%)
Average SE of CLs and kind of optics of CLs, n (%)	Right eye $-2.76 \pm 2.75D$ (range +6.0/-12.0D) Left eye $-2.72 \pm 2.76D$ (range +5.75/-12.0D)  Spherical CL on both eyes, 259 (73%) Toric CL at least in one eye, 66 (19 %) No response, 29 (8 %)
Number of DDCLs in package, n (%)	30 CLs in package, 215 (61%) 90 CLs in package, 92 (26%) No response 47 (13%)
Manufacturer, n (%)	Alcon, 114 (32%) Johnson & Johnson, 106 (30%) Cooper Vision, 45 (13%) Bausch & Lomb, 28 (8%) Other manufacturers, 34 (10%) No response, 27 (8%)

**Table 3:** CL current wear pattern and the characteristic of CL worn.

Most importantly for the aim of the research, non-compliance, measured in terms of the frequency of DDCLs replacement as compared to MRRF, was reported by 22.6% of the interviewees (n=80); i.e., they had re-used their lenses at least once during the previous month. The other 274 (77.4%) respondents used their CL only once. The number of times they reused DDCLs in a month is reported in Figure 1, while the number of days they used the same CLs is reported in Figure 2. The main reason for non-compliance to replacement is shown in Figure 3.

#### 4.1 Factors affecting compliance

Through Logistic Regression Analysis, variables such as age, gender, experience of CL wear, vision defect, the number of years of wear, number of DDCLs in package (30 vs. 90 lens), type of DDCLs (spherical vs. toric) purchased and manufacturer were analysed in order to predict past compliance. Results showed that the model explained a non-significant proportion of variance (Nagelkerke R<sup>2</sup>=0.06, p = 0.15) and that none of the demographic predictors affected past compliance, as shown in Table 4.

		% Compliant	% Non Compliant	N	B (SE)	Wald	p	OR (CI)
Gender	Male	72.4	27.6	349	-0.38 (0.29)	1.68	0.20	0.68 (0.38- 1.22)
	Female	80.4	19.6					
Age (years)	<20	66.0	34.0	347	-0.19 (0.13)	2.23	0.14	0.83 (0.64-1.10)
	20-27	75.3	24.7					
	28-35	78.1	21.9					
	36-43	81.1	18.9					
	>43	81.9	18.1					
Experience of CL wear (years)	Up to 3	77.5	22.5	328	-0.03 (0.05)	0.45	0.50	0.97 (0.88-1.07)
	4-6	70.1	29.9					
	7-9	72.5	27.5					
	10-12	68.6	31.4					
	More than 12	86.7	13.3					

DDCL Type	Spherical	78.4	21.6	325	-0.23 (0.37)	0.38	0.54	0.80 (0.39-1.64)
	Toric	78.8	21.2					
Mean Spherical Equivalent	0.00/+6.00 D	75.8	24.2	325	-0.09 (0.21)	0.18	0.68	0.92 (0.61-1.38)
	-0.25/-3.00 D	77.1	22.9					
	-3.00/-6.00 D	78.3	21.7					
	-6.00/-12.00 D	89.3	10.7					
Number of DDCLs in package	30	76.7	23.3	307	-0.54 (0.35)	2.48	0.12	0.58 (0.30-1.14)
	90	83.7	16.3					
Manufacturer	Alcon	79.8	20.2	327	-0.02 (0.10)	0.04	0.85	0.98 (0.81-1.19)
	Bausch & Lomb	78.6	21.4					
	Cooper	62.2	37.8					
	J&J	84.0	16.0					
	Other	76.5	23.5					

**Table 4:** Percentage of past compliance behaviour as a function of gender, age, experience of CL wear, optic type, mean spherical equivalent, kind of package of DDCLs and manufacturer of DDCL purchased, with logistic regression statistics for each variable.

To compare the predictive power of the TPB (excluding attitudes) and HBM, two logistic regression models were constructed, using six predictors: behavioural control and subjective norms (for TPB), susceptibility, severity, benefit perceived and barriers perceived (for HBM). Each model used two different criteria: 1) future intentions to replace DDCLs daily, 2) retrospective perception of past compliance in replacing DDCLs daily. The correlation matrix of the variables included in the model is presented in Table 5.

	Mean	SD	1 Susceptibility	2 Severity	3 Benefit perceived	4 Barriers perceived	5 Subjective Norms	6 Behavioural Control
1. Susceptibility	2.48	1.05	1					
2. Severity	3.66	1.00		0.27**		1		

3. Benefit perceived	3.82	0.90	0.09	0.24**	1		
4. Barriers perceived	2.60	1.00	0.11	0.11*	-0.03	1	
5. Subjective Norms	2.29	1.08	0.01	0.28**	0.29**	-0.03	1
6. Behavioural Control	4.17	1.06	-0.07	0.20**	0.34**	-0.05	0.51**

\*\* p < 0.01; \* p < 0.05

**Table 5:** Mean, standard deviation and Spearman correlation matrix among variables for predictors, criteria and control variables of the regression models (N=314).

The first model used "future intention to comply" as criteria. Because the frequency distribution was highly asymmetrical, the "future intentions" variable was dichotomized as "1" for those that answered 5 ("definitely yes", 70.9%) and all others who answered lower than 5 as "0" (29.1%).

Results of non-parametric logistic analysis, showed that the model explained a statistically significant proportion of variance (Negelkerke R<sup>2</sup>=0.45, p <0. 001), and that the best predictor was the TPB variable, subjective norms (B = 0.83; SE = 0.15; Wald = 27.66; p < 0.001), closely followed by behavioural control (B = 0.71; SE = 0.16; Wald = 18.80; p < 0.001) (see Table 6). For the HBM, only severity (i.e. perceived gravity of CL-related infection) had a significant influence on intentions, although with a smaller effect (B = 0.36; SE = 0.18; Wald = 4.12; p < 0.05). The other HBM variables were not significant: susceptibility (B = -0.15; SE = 0.17; Wald = 0.80; p = 0.37), perceived benefit (B = 0.21; SE = 0.19; Wald = 1.13; p = 0.29) and perceived barriers (B = -0.10; SE = 0.16; Wald = 0.40; p = 0.53) (Table 6).

	Predictors	B (SE)	Wald	OR (95% CI)
<i>Health Beliefs Model (HBM)</i>	<b>Susceptibility</b>	-0.15 (0.17)	0.80	0.86 (0.62 - 1.19)
	<b>Severity</b>	0.36 (0.18)	4.12*	1.44 (1.02 -2.05)

	<b>Benefit perceived</b>	0.21 (0.19)	1.13	1.23 (0.84 – 1.79)
	<b>Barriers perceived</b>	-0.10 (0.16)	0.40	0.91 (0.67 – 1.23)
<i>Theory of Planned Behaviour (TPB)</i>	<b>Subjective Norms</b>	0.83 (0.15)	27.66***	2.30 (1.69 – 3.13)
	<b>Behavioural Control</b>	0.71 (0.16)	18.80***	2.03 (1.47 – 2.80)

Legend: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $< 0.001$

**Table 6.** Regression model results for future intentions to comply (N=314).

For past compliance, the model showed a comparable proportion of variance explained (Negelkerke  $R^2=0.37$ ,  $p < 0.001$ ). The TPB measures were again strong predictors but, in this case, behavioural control was stronger ( $B = 0.67$ ;  $SE = 0.16$ ;  $Wald = 17.11$ ;  $p < 0.001$ ) than subjective norms ( $B = 0.41$ ;  $SE = 0.15$ ;  $Wald = 7.72$ ;  $p = 0.005$ ). For HBM, both severity ( $B = 0.63$ ;  $SE = 0.19$ ;  $Wald = 11.28$ ;  $p = 0.001$ ) and perceived benefit (i.e., the possibility of preventing a CL-related eye infection) ( $B = 0.40$ ;  $SE = 0.19$ ;  $Wald = 4.53$ ;  $p = 0.033$ ) were significant. At the same time, susceptibility to an eye infection ( $B = -0.11$ ;  $SE = 0.18$ ;  $Wald = 0.36$ ;  $p = 0.55$ ) and perceived barriers to prevention ( $B = -0.12$ ;  $SE = 0.16$ ;  $Wald = 0.54$ ;  $p = 0.46$ ) were not significant (Table 7).

	<i>Predictors</i>	<i>B (SE)</i>	<i>Wald</i>	<i>OR (95% CI)</i>
<i>Health Beliefs Model (HBM)</i>	<b>Susceptibility</b>	-0.11 (0.18)	0.36	1.11 (0.78 - 1.58)
	<b>Severity</b>	0.63 (0.19)	11.28**	0.54 (0.37 - 0.77)
	<b>Benefit perceived</b>	0.40 (0.19)	4.53*	0.67 (0.47 - 0.97)
	<b>Barriers perceived</b>	-0.12 (0.16)	0.54	0.46 (0.82 – 1.54)
<i>Theory of Planned Behaviour (TPB)</i>	<b>Subjective Norms</b>	0.41 (0.15)	7.72**	0.66 (0.37 - 0.70)
	<b>Behavioural Control</b>	0.67 (0.16)	17.11***	0.51 (0.49 - 0.89)

*Legend:* \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $< 0.001$

**Table 7.** Regression model results for past frequency of compliance (N=317).

## 5. Discussion

The aim of the research was to investigate compliance rates with daily disposable contact lens wear in Italy. Moreover, as previous studies highlighted the importance of health attitudes in the CL domain, the second aim was to test which specific wearer attitudes toward CL use affect the compliance rate.

In spite of DDCLs' potential benefits, non-compliance in terms of the correct frequency of replacement is widespread [6, 7, 8, 9, 10]. The results of the present study, conducted in Italy, support this, as 22.6% of wearers re-used DDCLs at least once. The percentage of non-compliant patients in Italy is higher than seen in some studies [6, 7, 8, 13, 14] but lower than in others [12, 13]. It should be noted that the level of compliance measured in the present study was measured relative to the MRRF, but we did not investigate whether the CLs wearers interviewed received different instructions from their practitioners in comparison to the MRRF. It has been demonstrated that this aspect can decrease the compliance level by about 3% [7].

This study also investigated the frequency of DDCL re-use, and 17% of those using this modality admitted to having used their lenses more than once in the last month (Figure 1). Furthermore, 4% of DDCL wearers reported re-use of the same lenses on 3 days or more (i.e. 4 days or more in total) (Figure 2). Although DDCL wearers have a lower level of non-compliance compared to two-week CL wearers [7, 13], this study underlines that non-compliance with DDCLs is also widespread.

Similar to results from other studies [13], the most important reason for non-compliance given in Italy was "to save money" (35%) (Figure 3). This study was conducted at a time of economic downturn, and it is possible that the level of compliance may have been influenced by this factor. Moreover, about one out of four non-compliant wearers said that they re-used their lenses because they believed no harm was incurred by wearing them for longer than recommended. This is likely due to a lack of understanding concerning the potential risks linked to reuse, rather than known risk-taking behaviour [28], but future studies are needed to understand this decision making process.

A further result of our study is the notable absence of any effect of demographic factors on compliance. Although, in a limited number of previous studies, it was reported that

some demographic factors, especially age, can affect compliance [10, 29, 30, 31], in many others, this relationship has not been found [1, 8, 28, 32].

Considering the weakness of demographic factors in affecting compliance, researchers have started to look at the further insights that might be provided by psychological factors [23, 28, 33]. In this vein, in our study, we have chosen to analyse psychological constructs that may also be powerful predictors of compliance with prescription in health related behaviours [20]. From this point of view, both TPB and HBM have been used in order to predict health compliance in different health related areas [21, 22] but never used to study incorrect replacement of CLs. Claydon and Efron [33] adapted a model used in general health care, the HBM, to predict compliance, and this was used in the current study to evaluate the ability of its different areas (susceptibility, severity, perceived benefits and perceived barriers) to predict compliance. The results show that future intention was only predicted by severity, (i.e. the perceived gravity of CL-related infection), while past compliance was predicted by both perceived benefits and severity.

It could be useful for eye care practitioners to bear these predictive factors in mind in order to increase the level of patient compliance, as it appears patients often underestimate the potential risks of DDCL misuse. Nevertheless, in addition to the threat of potential risks, the data suggest that noncompliance might also be reduced by emphasising the fact that, when properly used and with strict adherence to replacement schedules, DDCLs may help lower the risk of eye infection.

The second model, the TPB, has not previously been used in CL care and practice but seemed to perform better at explaining the behaviours underpinning compliance. However, the predictive strength of each of the two components studied (subjective norms and perceived behavioural control) varied between past compliance and future intention to comply. Subjective norms (social influence) had a stronger impact on future intentions to comply. However, for past compliance behaviour, "perceived behavioural control" was the stronger predictor with respect to DDCLs rate of re-use. Despite this, subjective norms remained a strong and significant predictor. Given the effectiveness of the model, results also suggest that future studies might also usefully include the TPB's general attitude towards compliance [17, 18].

The involvement of subjects socially close to the wearers strongly affects compliance and, thus, these subjects should be involved directly (especially the families of younger wearers) or indirectly, in making recommendations to the wearer. It would also be interesting for future studies to investigate the relationship between the CL wearer and those social groups (parents, siblings or peers) able to influence his/her level of compliance, in order to have a

better understanding of how to improve the compliance rate. Finally, the results highlight the importance of perceived behavioural control. Thus, in order to comply, wearers should see themselves as being in control of the daily replacement of their lenses and of the associated procedures, and these should be viewed as easily implementable.

This study also demonstrated that, in Italy, as in other countries, non-compliance with the MRRF of DDCLs is widespread (23%), however, knowledge of the wearer's health beliefs might be useful to evaluate how to improve compliance. As suggested by Efron [23], practitioners often tend to blame the patient for non-compliance, instead of understanding the underlying reasons. Cognitive and behavioural reasons often stem from core attitudes toward compliance [23, 28, 33]. Hence, from a practical point of view, the results underline the role of emphasising behavioural control, rather than highlighting threats, in encouraging compliance with recommended CL replacement rates. Therefore, eye care practitioners, CL manufacturers or those planning awareness or advertising campaigns, should aim at forming and strengthening positive attitudes towards correct procedures for re-using DDCLs, by focusing on the potential benefits of behavioural control rather than emphasising the negative outcomes of non-compliant behaviour. Moreover, because the subjective norms were a significant predictor of compliance, practitioners should both aim at improving the explicit support provided by significant others (other family members or peers) in the re-use of DDCLs and emphasise the significant others' positive opinions toward correct DDCL use.

## References

1. Collins MJ, Carney LG. Patient compliance and its influence on contact lens wearing problems. *Am J Optom Physiol Optics* 1986;63:952-956.
2. Lam DSC, Houang E, Fan DSP, Lyon D, Seal D, Wong E. Incidence and risk factors for microbial keratitis in Hong Kong: comparison with Europe and North America. *Eye* 2002;16:608-618.
3. Weissman BA, Mondino BJ. Risk factors for contact lens associated microbial keratitis. *Contact Lens Anterior Eye* 2002;25:3-9.
4. Dart, JKG, Radford CF, Minassian D, Verma S, Stapleton F. Risk factors for microbial keratitis with contemporary contact lenses: a case-control study. *Ophthalmology* 2008;115:1647-1654.
5. Stapleton F, Keay L, Jalbert I, Cole N. The epidemiology of contact lens related infiltrates. *Optom Vis Sci* 2007;84:257-272.
6. Donshik PC, Ehlers WH, Anderson LD, Schecki JK. Strategies to better engage, educate, and empower patient compliance and safe lens wear: compliance: what we know, what we do not know, and what we need to know. *Eye & Contact Lens* 2007;33:430-433.
7. Dumbleton K, Woods C, Jones L, Fonn D, Sarwer DB. Patient and practitioner compliance with silicone hydrogel and daily disposable lens replacement in the United States. *Eye & Contact Lens* 2009; 35:164-171.
8. Yeung KK, Forister JF, Forister EF, Chung MY, Han S, Weissman BA. Compliance with soft contact lens replacement schedules and associated contact lens-related ocular complications: The UCLA Contact Lens Study. *Optometry-Journal of the American Optometric Association* 2010;81:598-607.
9. Hickson-Curran S, Chalmers RL, Riley C. Patient attitudes and behavior regarding hygiene and replacement of soft contact lenses and storage cases. *Contact Lens Anterior Eye* 2011; 34: 207-215.
10. Dumbleton K, Richter D, Bergenske P, Jones, LW. Compliance with lens replacement and the interval between eye examinations. *Optom Vis Sci* 2013;90:351-358.

11. Chalmers RL, Keay L, McNally J, Kern J. Multicenter case-control study of the role of lens materials and care products on the development of corneal infiltrates. *Optom Vis Sci* 2012;89:316-25
12. Boost M, Poon KC, Cho P. Contamination risk of reusing daily disposable contact lenses. *Optom Vis Sci* 2011;88:1409-1413.
13. Dumbleton K, Richter D, Woods C, Jones L, Fonn D. Compliance with contact lens replacement in Canada and the United States. *Optom Vis Sci* 2010;87:131-9.
14. Richter D, Dumbleton K, Guthrie S, Woods C, Jones L, Fonn D. Patient and practitioner compliance with silicone hydrogel and daily disposable lens replacement in Canada. *Canadian Journal of Optometry Can J Optom* 2009;35:164–71.
15. Dumbleton KA, Richter D, Woods CA, Aakre BM, Plowright A, Morgan PB, Jones LW. A multi-country assessment of compliance with daily disposable contact lens wear. *Cont Lens Anterior Eye* 2013;36:304-12.
16. Becker MH. The health belief model and personal health behavior. *Health Education Monographs* 1974;2:336-353.
17. Ajzen I. The theory of planned behaviour. *Organizational behaviour and human decision processes* 1991;50:179-211.
18. Conner M, Sparks P. Theory of planned behavior and health behaviors. In: Conner M, Norman P, editors. *Predicting health behaviour*. Buckingham: Open University Press; 1996, pp. 121–162.
19. Şimşekoğlu Ö, Lajunen T. Social psychology of seat belt use: A comparison of theory of planned behavior and health belief model. *Transportation Research Part F: Traffic Psychology and Behaviour* 2008;11:181-191.
20. Noar SM, Zimmerman RS. Health Behavior Theory and cumulative knowledge regarding health behaviors: are we moving in the right direction? *Health education research*, 2005, 20.3: 275-290.
21. Godin G, Kok G. The theory of planned behavior: a review of its applications to health-related behaviors. *American Journal of Health Promotion* 1996;11:87-98.
22. Sheeran P, Abraham C. The health belief model. *Predicting health behaviour*, 1996; 2:29-80.
23. Efron N. The truth about compliance. *Contact Lens and Anterior Eye* 1997;20:79-86.

24. Zeri F, Livi S, Cesari M, Gheller P, Magni R. Benefits and barriers towards the use of contact lenses. how ametropes perceive them and how practitioners inform about them: An Italian survey. *Contact Lens and Anterior Eye*, 2015, 38: e40-e41.
25. Zeri F, Di Censi M, Livi S, Calcatelli P. Identikit of a successful contact lenses wearer with presbyopia. *Contact Lens and Anterior Eye*, 2013, 36: e33-e34.
26. Zeri F, Livi S, Maffioletti. Attitudes towards visual correction in sport: What coaches, physical education teachers and sports physicians think. *Contact Lens and Anterior Eye*, 2011, 34.2: 71-76.
27. Zeri F, Durban JJ, Hidalgo F, Gispets J, Contact Lens Evolution Study Group. Attitudes towards contact lenses: A comparative study of teenagers and their parents. *Contact Lens and Anterior Eye*, 2010, 33.3: 119-123.
28. Carnt N, Keay L, Willcox M, Evans V, Stapleton F. Higher risk taking propensity of contact lens wearers is associated with less compliance. *Contact Lens and Anterior Eye* 2011; 34: 202-206.
29. Chun MW, Weissman BA. Compliance in contact lens care. *American Journal of Optometry and Physiological Optics*, 1987, 64.4: 274-276.
30. Sokol JL, Mier MG, Bloom S, Asbell PA. A study of patient compliance in a contact lens-wearing population. *The CLAO J* 1989; 16: 209-213.
31. Jansen ME, Chalmers R, Mitchell GL, Kinoshita BT, Lam DY, McMahon TT, Richdale K, Sorbara L, Wagner H. Characterization of patients who report compliant and non-compliant overnight wear of soft contact lenses. *Contact Lens and Anterior Eye*, 2011, 34.5: 229-235.
32. Radford CF, Woodward EG, Stapleton F. Contact lens hygiene compliance in a university population. *J Br Contact Lens Assoc* 1993; 16: 105-111.
33. Claydon BE, Efron N. Non compliance in contact lens wear. *Ophthalmic and Physiological Optics*, 1994, 14.4: 356-364.

### Captions

Figure 1: Answers (%) at the question " If you reused your CLs, how many times did you do so in the last month?". Data are percentage of total number of DDCL wearers (n=354).

Figure 2: Answers (%) at the question " If you reused your CLs, how many days on average did you reuse the same lenses in the last month?" Data are percentage of the total number of DDCL wearers (n=354).

Figure 3: Reason for re-use of DDCLs. Data are percentage of the total number of non-compliant DDCL wearers (n=80).





