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Clinical breakage, slippage and acceptability of two commercial ultra-thin polyurethane male condoms compared to a commercial thin latex condom: a randomised, masked, 3 way crossover, multi centre controlled study (SAGCS 2)

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Abstract

Background Although natural rubber latex remains dominant as the primary manufacturing material for male condoms synthetic materials first introduced in the early 1990s address many of the limitations of latex including the risk of allergies. Polyurethane elastomers allow condoms to be made significantly thinner to provide greater sensitivity and encourage greater use of condoms for contraception and STI prophylaxis.

The primary objective of this Study was to evaluate the breakage, slippage and acceptability of two ultra-thin polyurethane condoms against a thin control latex male condom, designated latex C, in a randomized, cross over, masked, non-inferiority study. The condom designated Polyurethane A was designed for markets where 52/53 mm wide latex condoms are preferred whereas the condom designated Polyurethane B was designed for markets where the smaller 49 mm wide latex condom is preferred.

Methods The Study was designed to meet the requirements specified in ISO 29943–1: 2017 and FDA guidelines for clinical studies on synthetic condoms. It was conducted by two Essential Access Health centres, one in Northern California and the other in Southern California. Sexually active heterosexual couples (300) aged between 18 and 45 years were recruited to use three sets of five condoms in a block randomized order, recording breakage, slippage and acceptability after each use. A total of 252 couples contributed 2405 evaluable condom uses per protocol for the Condom A versus Latex C comparison (1193 Polyurethane A plus 1212 Latex C), and 247 couples provided 2335 evaluable condom uses per protocol for the Condom B versus Latex C comparison (1142 Polyurethane B plus 1193 Latex C). Only condoms used for vaginal intercourse were included in the analysis.

Findings Although the total failure rates (breakage and slippage) for the polyurethane condoms were higher than for the control Latex C condom, all condoms performed extremely well with low failure rates compared to similar condom studies. Condom Polyurethane A met the noninferiority requirements specified in ISO 23409:2011

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relative to Latex C, the control NR latex condom, in the full Study population. While condom Polyurethane B did not meet the noninferiority requirement for the full Study population, it did meet the noninferiority requirement when analysis was restricted to the intended population (men with penis lengths ≤ 170 mm).

Trial registration The Study is registered with ClinicalTrials.gov, NCT04622306, Protocol Reference SAGCS 2, initial release date 11/02/2020.

Introduction

Natural rubber (NR) latex condoms are widely available and accessible. Condoms remain the only reversible method of contraception for men, as well as being an effective means of preventing sexually transmitted infection (STI) including the transmission of human immunodeficiency virus (HIV), which can progress to AIDS.

Limitations of NR latex condoms include loss of physical performance as manufacturers strive to make them thinner so as to improve sensitivity. Also, NR latex products have the potential to induce allergies including the risk of dermatitis, caused by some of the chemicals used in the latex formulations. Latex allergies result in many people not being able to use latex products. As reported by Parisi et al. [1], this can be up to 7·4% of the General Population and between 15 and 50% of some Healthcare Professions.

The development of synthetic condom options starting in the early 1990s allowed many of the issues associated with NR latex condoms to be addressed. Synthetic condoms made from polyurethane elastomers can be made significantly thinner to increase sensitivity while maintaining performance and protection from STIs and pregnancy. In addition, these condoms are latex protein free, hypoallergenic, and capable of withstanding environmental extremes.

This paper reports the clinical evaluation of two commercial ultra-thin polyurethane condoms that are claimed to offer greater sensitivity and more sensation than conventional latex condoms as well as extending the choice of condom sizes available for men who need a smaller condom.

Objective

The primary objective of this Study was to determine the total clinical failure rates (combined breakage and slippage) of two ultra-thin commercially available polyurethane male condoms versus a thin natural rubber (NR) latex control condom and assess conformance with the non-inferiority requirements specified in Clause 10 of ISO 23409:2011 [2] Secondary objectives included collecting information about acceptability and user preferences.

Materials and methods

Condoms

The polyurethane condoms used in this Study were manufactured by Sagami Manufacturers Sdn., Bhd., Malaysia. The first polyurethane condom, designated Polyurethane A, is 0·024 mm thick, 190 mm long, and has a lay flat width of 58 mm. This condom is designed for markets where 52/53 mm wide latex condoms are preferred and has been sold on the Japanese market for 12 years before the start of the Study. The second, smaller, polyurethane condom, designated Polyurethane B, is 0·018 mm thick, 170 mm long, and width of 55 mm. This smaller condom is designed for markets where 49 mm wide latex condoms are preferred. This condom has been sold on the Japanese market for 10 years prior to the start of the Study.

The control NR latex condom was manufactured by Sagami Rubber Industries Co., Ltd., in Japan. This condom, designated control Latex C, is a thin commercial NR latex male condom which is 0·055 mm thick, 195 mm long, and has a 53 mm lay flat width. Latex C had been previously marketed in the USA as Trojan Thintensity™, FDA 510(k) premarket notification clearance K073016). Latex C is typical of thin NR latex condoms currently on the market. For comparison, the nominal thickness of a standard Sagami latex condom is 0.070 mm.

All three types of condoms were lubricated with silicone lubricant with a specified viscosity of 100 cSt and were packed in plain sachets. The properties of all three condoms are summarised in Table 1.

All Study participants were provided with 4 oz (113.6 ml) samples of water based personal lubricant (Astroglide ™) to standardise the additional lubricant used with the condoms should the users require extra lubrication.

Study designs

The Study design complied with the recommendations of the FDA guidelines for clinical studies on synthetic condoms [3] and ISO 29943 -1:2017 [4]. The Study is registered on the clinicaltrials.gov website with the identifier NCT04622306, initial release date 11/02/2020. The protocol, SAGCS 2, is published on the clinicaltrials.gov site.

Table 1 Summary of the properties of the study condoms (Note: Polyurethane (PU))

Property	PU A	PU B	Latex C
Mean length (mm)	190 ± 10	170 ± 10	195 ± 10
Mean lay flat width (mm)	58 ± 2	55 ± 2	53 ± 2
Mid body thickness (mm)	0.024 ± 0.008	0.018 ± 0.008	0.055 ± 0.01
Mean burst volume (l)	8.48	6.48	29.67
Mean burst pressure (kPa)	4.74	3.45	1.69
Mean force at break (N)	97.3	67.7	48.3
Mean elongation at break (%)	580	568	690
Lubricant type	Silicone	Silicone	Silicone
Lubricant viscosity (cSt)	100	100	100
Lubricant quantity (g)	0.40–0.60	0.40–0.60	0.40–0.60

The Study was conducted by Essential Access Health, Los Angeles, California (EAH). It was subject to review and oversight by the EAH Institutional Review Board (IRB). The Study was approved by the EAH IRB in May 2020.

Power calculations and sample size

The number of couples required was determined using the power calculations given in Annex A of ISO 29943–1:2017. The Bonferroni correction was used to maintain the power of the three-arm study. Therefore, the one-sided upper limits of the 97·5% confidence intervals for the difference in total clinical failures rates between the polyurethane condoms and the latex control condom were used to assess non-inferiority rather than the one-sided upper limits of the 95% confidence intervals as specified in the FDA guidance document and ISO 23409:2011. The use of the Bonferroni correction and amended 97·5% confidence limits were agreed in advance with the US FDA in a 510(k) pre-submission. The non-inferiority margin of 2·5% specified in ISO 23409:2011 was used for the assessment. To meet the non-inferiority requirement, therefore, the upper 97·5% bound of the one-sided confidence interval for the difference in total clinical failure rates was required to be equal to or less than 2·5%.

The pre-study sample size calculations were based on a power estimate of 95% rather than the more usual 80% to allow for potentially higher rates of early discontinuations and loss to follow up given the three-arm design. These calculations indicated a minimum of 1274 uses of each condom type provided by enrolling 300 couples would be required to achieve the power estimate of 95%.

Recruitment

Volunteer couples were recruited by EAH in two centres, Los Angeles and Berkeley California, USA between October 2020 and August 2021 primarily through recruitment campaigns in social media. Follow up was completed by October 2021 when the target number of condom uses had been achieved. The recruitment criteria required individuals to be in the age range 18–45 years old, to be in monogamous heterosexual relationships and to be protected against pregnancy by oral contraceptives, IUDs, implants, contraceptive injections, contraceptive patches, or sterilization (tubal ligation or vasectomy). Exclusion criteria included couples at significant risk of STIs including HIV or having a medical history of recurrent, uncontrolled STIs (e.g., gonorrhoea, syphilis, chlamydia, etc.).

Ethics approval and consent to participate

The study was reviewed and approved by the EAH Institutional Review Board (IRB) in accordance with FDA regulations (21 CFR Part 50, 21 CFR Part 56 and 21 CFR Part 812). Copies of the IRB approval letter and the IRB approved consent form are held on file by EAH.

After initial telephone screening subjects were emailed a copy of the consent form and invited to attend a consent visit at which they were briefed about the objectives of the study and advised that details about their sexual activities would be collected. Both the subject and partner were required to sign consent forms electronically using Part 11 compliant software.

Consent for publication

No details, images, or videos relating to any individual participant in the study are included in this paper from which that individual can be identified. Individual consent for publication is not therefore considered necessary.

Randomisation and masking

Each couple was asked to use five each of the three types of condoms. Couples were randomly assigned to one of the 6 possible sequence combinations, i.e., ABC, ACB, BAC, BCA, CAB, CBA. The random allocation sequence was generated by EAH using SAS software with a block size of 12. The numbers of couples assigned to each sequence were approximately equal (range 48–53) as were the numbers completing usage of each sequence (range 45–51).

All condoms were packed in plain sachets to mask the identity of the condoms from the subjects and investigators. The plain sachets carried a simple identification code that was not disclosed to the investigators until the Study had been completed.

Since the condom types were masked and men were randomly assigned to use all three condom types irrespective of penis size, men with larger penises were

therefore required to use the smaller Polyurethane B condom which may have been too small for them. It was expected, therefore, that some men would find Polyurethane B to be difficult to put on as well as too tight and uncomfortable during use. In practice therefore, when condoms are being used for protection, clinical failure rates may be lower.

Study procedure

The worldwide COVID-19 public health emergency was ongoing for the duration of the Study. Study procedures, in compliance with state and local policies for COVID-19 infection control, were aimed at protecting trial participants and Study staff by reducing the risk of Covid 19 transmission. Therefore, remote visits via videoconference or telephone were used for recruitment, consenting, interviews, and training. Research staff conducted consent meetings remotely via videoconference with both partners present. Study condoms, materials, and data forms were exchanged at curb side visits to minimise contact and reduce the risk of virus transmission.

Following pre-screening, EAH invited eligible couples to a remote consent meeting at which the informed consent forms were signed electronically. After signing the informed consent forms, both partners viewed a video which demonstrated the correct way to put on and remove condoms. Research staff instructed couples to withdraw the penis completely from the vagina soon after ejaculation while the penis is still erect and to hold the condom firmly in place at the base of the erect penis during withdrawal (ISO 23409:2011 clause 6.2.3.3.d). Couples were instructed on how to take erect penis measurements using a penis measurement kit. Research staff provided instruction on completing all self-administered data collection forms.

At the first curb side enrolment visit couples were given a penis measurement kit to measure the male's erect penis (length and circumference) prior to use of the first Study condom. They also received the first set of five Study condoms and five blank condom report forms that were to be completed within 30 min of ejaculation. At every follow-up curb side visit, participants returned the condom report forms for each Study condom used. These condom reports elicited information on the conditions of use (who put on condom, use of lubrication, duration of vaginal intercourse, positions used during intercourse), subjective impression (stimulation and quality of lubricant), whether the condom was held at the base of the erect penis during withdrawal, and problems encountered (breakage, slippage, discomfort, lack of lubrication), and details of problems encountered, such as when noticed and duration. Written instructions and definitions/illustrations of potential condom problems such as breakage and slippage were attached to the condom report forms.

After using each set of five condoms, partners also completed acceptability questionnaires regarding their overall experience with each type of condom and returned the questionnaires at the next follow-up curb side visits. These self-administered questionnaires, completed independently by both partners, elicited perceived advantages, disadvantages, problems, and physical reactions related to condom use.

At the final curb side visit each partner returned a completed comparison form that elicited condom preferences including sensation, comfort, lubrication, fit, ease of use, overall preference.

Couples returned condoms that they claimed were broken in double sealed plastic pouches provided by EAH. At the close of the Study, the pouches were placed in single large sealable plastic bags and then inside heavy-duty cardboard shipping boxes and sent to Sagami Japan for evaluation.

Results

Data analysis

EAH performed data coding, editing, and key entry using Entrypoint Plus software. The Study Director and Clinical Director reviewed masked Study summary data to monitor progress of the Study.

Following completion of participant follow-up and data collection, initial analysis of the results was completed by EAH. A statistician at FHI 360 was contracted to complete the primary non-inferiority analysis in SAS/STAT software using GEE (Generalized Estimating Equations) with identity link function, independent working correlation matrix, and robust variance estimation to account for repeated measures for each couple. Secondary analyses were conducted by EAH using chi-squared tests without continuity correction. Unless otherwise stated, chi-squared tests were conducted using three-way contingency tables comparing results across all three condom types.

Recruitment & selection

The Study met the recruitment target of screening and consenting 300 couples. Out of the 300 couples consented, 44 exited early. Reasons for early exit are given in Table 2.

A total of 256 couples completed the Study using at least one condom of each type. Also included in the secondary analyses but not in the primary non-inferiority analysis were couples who used at least one condom of any type. Further details about the number of couples and rates of early exit are given in Table 2.

Table 2 Number and percent of couples by data completion status

	Couples	
	n	%
Total enrolled	300	100.0
Exited early	44	14.7
No longer with Study partner	14	4·7
Study complaint[1]	2	0·7
Moved out of area	2	0·7
Condom discomfort	2	0·7
Disliked Study condoms	3	1·0
Unrelated health problem	3	1·0
Did not use last condom set before end of follow-up period	1	0·3
Eligibility issue[2]	1	0·3
Personal reason[3]	13	4·3
Lost to follow-up	3	1·0
Completed study[4]	256	85.3

[1] Study takes too much time, too many visits, etc.

[2] Male partner reported history of latex allergy after receiving first set of condoms, did not use any Study condoms

[3] Examples include new job, no sex, too busy/no time for Study, personal problems, lost interest in Study

[4] Used at least one condom of each type

Population information

A summary of the ages and sociodemographic characteristics of the recruited Study population is given in Table 3.

The mean age for men was 28.0 years and for women 26.4 years, yielding an overall mean of 27.2 years. The main ethnic groups were white (45%), Hispanic (24%), and Asian (13%). The remainder (18%) included African Americans (4%).

Information about the sexual and reproductive histories of the participants is given in Table 4.

Intercourse frequency varied from more than 10 times per month for 49% of the couples down to 4–6 times per month for 22% of the couples. A total of 60% of the couples reported never or rarely using an additional lubricant during intercourse with 21% reporting occasional use of lubricants and 20% often using them. Of the males, 59% were circumcised.

Experience with condoms is reported in Table 5.

All of the participants had used condoms in the past with 52% reporting using more than 50 uses and 36% reporting between 11 and 50 uses. Reports of past condom breakages with the Study partner were low: 72% reported no previous breaks and 22% reported between one or two breaks. Three couples (1%), however, reported more than 10 previous condom breaks with the Study partner. A further couple, who reported breaking 6 out of the 14 Study condoms used during the Study, reported a history of breaking condoms but the exact number of breaks is unknown.

Erect penis size was measured by the couples using two strips of paper. The results, analysed by quartile, are summarised in Table 6. The median penis length was 156 mm and the median circumference 129 mm.

Condom usage

The profile of Study condom uses is listed in Table 7.

The total number of Study condoms of each type available for use was 1500. Though Study participants were instructed to only use the Study condoms for vaginal intercourse, 6 condom uses were excluded from the analysis due to anal use and 15 for oral use. A further 22 condom uses were excluded because the couples used a personal lubricant product other than the one supplied with the Study condoms.

Early discontinuation for personal reasons, failure to use the condoms as instructed, or incomplete/incorrect completion of the condom reports reduced the number of Polyurethane A uses to 1305, Polyurethane B uses to 1309, and control Latex C uses to 1320. After excluding condoms that were not used for vaginal intercourse for various reasons such as difficulty unrolling the condoms onto the penis, tearing the condoms during donning, and condoms that were considered too tight to be donned, the final number of potentially evaluable condoms were 1221 for Polyurethane A, 1183 for Polyurethane B, and 1268 for Latex C. Fewer of the smaller sized Polyurethane B condoms were used, presumably due to their restrictive size.

Details of how these condoms were used are listed in Table 8.

The average length of intercourse was 13.3 min for Polyurethane A, 13.3 min for Polyurethane B, and 13.2 min for Latex C.

Since the statistical analysis plan in the protocol required the use of at least one control and one test condom for the non-inferiority analyses, there were further reductions in the number of condoms included in the non-inferiority comparisons of Polyurethane A versus Latex C and Polyurethane B versus Latex C. For the Polyurethane A versus Latex C comparison, the number of evaluable uses of Polyurethane A was 1193 and the number of evaluable uses of Latex C was 1212. For the Polyurethane B versus Latex C comparison the number of uses of Polyurethane B was 1142 and uses of Latex C was 1193. Full details of the non-inferiority analysis are summarised in Table 11.

The numbers of condoms used were close to the target value of 1275 per condom type required to

Table 3 Sociodemographic Characteristics of Participants

	Male		Female		Combined	
	n = 300	%	n = 300	%	n = 600	%
Age						
21 or under	25	8	50	17	75	13
22–24	64	21	65	22	129	22
25–29	110	37	112	37	222	37
30–34	59	20	50	17	109	18
35 or over	42	14	23	8	65	11
Mean age (yrs.)	28		26.4		27.2	
Race/ethnicity						
White	146	49	125	42	271	45
Hispanic	74	25	70	23	144	24
African American	13	4	10	3	23	4
Asian	30	10	50	17	80	13
Other, multiple	37	12	45	15	82	14
Marital status/living arrangement						
Married					62	21
Single living with partner					156	52
Single living alone					82	27
Mean length of relationship (yrs.)					4.2	
Education						
High school graduate or less	51	17	36	12	87	15
Some college	107	36	102	34	209	35
College graduate	113	38	119	40	232	39
Postgraduate	29	10	43	14	72	12
Employment status						
Full-time	143	48	129	43	272	45
Part-time	53	18	54	18	107	18
Student	46	15	72	24	118	20
Not employed	58	19	45	15	103	17
Annual household income						
$0–20,000	42	14	53	18	95	16
$20,001–40,000	55	18	66	22	121	20
$40,001–60,000	57	19	59	20	116	19
Over $60,000	146	49	122	41	268	45
Smoking						
Never smoked	184	61	241	80	425	71
Former smoker	67	22	36	12	103	17
Current smoker	49	16	23	8	72	12
Alcoholic drinks						
None	26	9	34	11	60	10
Monthly	144	48	145	48	289	48
Weekly	119	40	113	38	232	39
Daily	11	4	8	3	19	3

Table 4 Sexual and reproductive history of participants

	Males		Females		Combined	
	n = 300	%	n = 300	%	n = 600	%
Lifetime sexual partners						
One	39	13	44	15	83	14
Two to four	60	20	69	23	129	22
Five to nine	67	22	67	22	134	22
Ten to fourteen	43	14	49	16	92	15
Fifteen to twenty-five	51	17	45	15	96	16
More than twenty-five	40	13	26	9	66	11
Mean number partners	12·6		10·6		11·6	
Intercourse frequency						
4–6 times per month					66	22
7–10 times per month					88	29
More than 10 times per month					146	49
Use of lubrication with intercourse						
Never					86	29
Rarely					92	31
Sometimes					63	21
Often					59	20
Difficulty getting erection in last 30 days						
Never	298	99				
Yes	2	1				
Circumcision						
Circumcised	176	59				
Not circumcised	124	41				
Mean penis length (mm)	157					
Mean penis circumference (mm)	130					
Number of pregnancies						
None	222	74	225	75		
One-two	73	24	71	24		
More than two	5	2	4	1		
Current birth control method						
Pills					111	37
Injection					6	2
Patch					7	2
IUD					125	42
Implant					39	13
Sterilization					12	4

achieve the 95% power value used in the original power calculations and comfortably exceeded the requirements of a minimum 1,000 uses per couple specified in ISO 29943–1:2017. Based on the original assumptions in the power estimates in the statistical analysis plan, the actual numbers of condoms used provided a power of at least 90%.

Clinical failure results

Details of the overall clinical failure rates (clinical breakage plus clinical slippage) for all evaluable condom uses is given in Table 9.

There were 31 total clinical failures for Polyurethane A (18 breakages and 13 slip offs), 36 total clinical failures for Polyurethane B condom (22 breakages and 14 slip offs) and 16 total clinical failures for control Latex C (10 breakages and 6 slip offs). The total clinical failure rates

Table 5 Condom experience of participants

	Males		Females		Combined	
	n = 300	%	n = 300	%	n = 600	%
Lifetime condom experience						
Never	0	0	0	0	0	0
1–2 uses	6	2	6	2	12	2
3–10 uses	23	8	40	13	63	11
11–50 uses	101	34	113	38	214	36
More than 50 uses	170	57	141	47	311	52
Last condom use						
Less than 6 months	110	37	101	34	211	35
6 months to 1 year	64	21	68	23	132	22
1–5 years	112	37	106	35	218	36
More than 5 years	14	5	25	8	39	7
Condom experience with study partner						
Never					27	9
1–2 uses					39	13
3–10 uses					75	25
11–50 uses					98	33
More than 50 uses					61	20
Condom breaks with previous partners						
No breaks	87	33	146	57	233	45
1–2 breaks	97	37	64	25	161	31
3–5 breaks	49	19	31	12	80	16
6–10 breaks	19	7	8	3	27	5
More than 10 breaks	9	3	5	2	14	3
Condom breaks with study partner						
No breaks					197	72
1–2 breaks					59	22
3–5 breaks					14	5
6–10 breaks					0	0
More than 10 breaks					3	1
Ever used polyurethane condom						
No	167	56	172	57	339	57
Yes	57	19	39	13	96	16
Unsure	76	25	89	30	165	28
Impression of polyurethane condom						
Negative	6	11	2	5	8	8
Positive	17	30	9	23	26	27
Neutral	34	60	28	72	62	65

Table 6 Distribution of study population penis size by quartile

Dimension	Minimum	Lower quartile	Median	Upper quartile	Maximum
Length (mm)	105	143	156	170	249
Girth (mm)	95	121	129	137	216

were 2.5% for Polyurethane A, 3.0% for Polyurethane B and 1.3% for Latex C.

The overall failure rates for Polyurethane A and Polyurethane B compare very favourably with results for synthetic condoms from previously published clinical functionality studies. Results from similarly powered randomised crossover studies using the same definitions of clinical failures are summarised in Table 10.

Table 7 Profile of Condom Use (Note: PU = Polyurethane)

	PU A		PU B		Latex C	
	n	%	n	%	n	%
Condoms available for use	**1500**		**1500**		**1500**	
Total condoms not opened/recorded	195	13.0	191	12.7	180	12.0
Due to early discontinuation[1]	160	10.7	150	10.0	155	10.3
Due to personal reasons	30	2.0	34	2.3	23	1.5
Due to failure to use condom per protocol [2]	5	0.3	5	0.3	0	0.0
Due to uninterpretable condom report	0	0.0	2	0.1	2	0.1
Total condoms opened & recorded	1305	87.0	1309	87.3	1320	88.0
Not used for vaginal intercourse	85	6.5	126	9.6	53	4.0
Defective	0	0.0	0	0.0	0	0.0
Tore while unwrapping	1	0.1	0	0.0	0	0.0
Could not unroll condom fully onto penis	51	3.9	98	7.5	21	1.6
Tore while donning	0	0.0	3	0.2	4	0.3
Condom too tight	14	1.1	13	1.0	6	0.5
Other reason	3	0.2	3	0.2	1	0.1
Used sharp object to unwrap condom[3]	2	0.2	1	0.1	0	0.0
Used for anal intercourse[3]	4	0.3	0	0.0	2	0.2
Used for oral intercourse[3]	3	0.2	3	0.2	9	0.7
Used non-Study lubricant[3]	7	0.5	5	0.4	10	0.8
Evaluable condom uses	1221	93·6	1183	90·4	1268	96·1
Failed during intercourse	31	2.5	36	3.0	16	1.3
Clinical break	18	1.5	22	1.9	10	0.89
Clinical Slippage	13	1.1	14	1.2	6	0.5
Did not fail during intercourse	1190	97·5	1147	97·0	1252	98·7
Tore during removal	1	0.1	1	0.1	0	0.0
Removed intact	1189	99·9	1146	99·9	1252	100·0

In particular, the results for Polyurethane A and Polyurethane B are substantially lower than the results obtained by Frezieres et al. for the polyurethane condoms reported in the 1998 and 1999 studies [2, 3], and in line with those obtained by Potter and Villemeur in 2003 [6]. The total clinical failure rate for the thin control Latex C also compares very favourably with the rates reported in Table 10 for the standard thickness latex control condoms used in those studies.

Non-inferiority analysis

Polyurethane A and polyurethane B condoms were assessed independently versus the control Latex Condom C for non-inferiority using the following hypotheses:

- Null Hypothesis, H_0: The one-sided 97·5% upper bound of the difference in test polyurethane condom total clinical failure rate – control natural rubber Latex Condom C total clinical failure rate $\geq \delta$, where $\delta = 2.5\%$ (δ is the non-inferiority margin specified in ISO 23409:2011).
- Alternative Hypothesis, H_A: The one-sided 97·5% upper bound of the difference in test polyurethane condom total clinical failure rate—control natural rubber latex condom total clinical failure rate $< \delta$, where $\delta = 2.5\%$.

As discussed in the section on power calculations, the Bonferroni correction was used to maintain the power of the three-arm study. Therefore, the one-sided upper limits of the 97·5% confidence intervals for the difference in total clinical failures rates between the polyurethane condoms and the latex control condom were used to assess non-inferiority rather than the one-sided upper limits of the 95% confidence intervals as specified in the FDA guidance document and ISO 23409:2011. Only condoms used for vaginal intercourse were included in the analysis.

Details of the non-inferiority analysis are summarised in Table 11.

A total of 252 couples contributed 2,405 evaluable uses per protocol for Polyurethane A versus control Latex

Table 8 Characteristics of use by condom type

	PU A n = 1221 %	PU B n = 1183 %	Latex C 1268 %
Characteristics of use (before intercourse)			
Use during menses	4	5	5
Who put condom on			
Male put condom on	73	76	77
Female put condom on[1]	17	13	13
Both partners put condom on	11	11	10
Applied lubricant before intercourse[1]	42	37	32
Characteristics of use (during intercourse)			
Started intercourse without condom[1]	7	10	9
Applied lubricant after starting intercourse[1]	28	29	24
Positions used during intercourse			
Man on top	68	67	64
Woman on top	44	47	44
Side by side	18	18	16
Rear entry	38	37	40
Lost erection[1]	3	4	5
Ejaculation			
Yes, while wearing condom	84	83	81
Yes, after removing condom[1]	11	14	14
No[1]	5	3	4
Held ring during withdrawal	81	79	82
Withdrew while still erect	91	92	90
Mean length of intercourse (minutes)	13·3	13·3	13·2

[1] Chi-square statistically different: p-value < 0.05

C. The total clinical failure rates for the condom uses included in the non-inferiority analysis were 2·35% and 1·32% respectively, resulting in a difference between the rates of 1·03%. The one-sided 97·5% upper bound on the difference (equivalent to the two-sided 95% upper bound) was 2·35%, which is less than the 2·5% non-inferiority margin specified in ISO 23409:2011. A conclusion of non-inferiority with respect to clinical failure was therefore demonstrated.

Although non-inferiority margins were not pre-specified for clinical breakage and clinical slippage individually, the upper bound of the confidence intervals for the difference in these rates were each less than 2%, the non-inferiority margin for breakage and slippage recommended in ISO 29943–1:2017. The Polyurethane A condom was therefore considered non-inferior to the control Latex C condom in terms of the individual clinical failure rates for breakage and slippage.

A total of 247 couples provided 2335 evaluable uses per protocol for Polyurethane B versus control Latex C non-inferiority comparison. The total clinical failure rates were 3·06 and 1·26% respectively, resulting in a difference in rates of 1·81%. The one-sided upper 97·5% bound on the difference was 3·23%, meaning that the null hypothesis that the Polyurethane B condom is inferior to the control Latex C condom with respect to total clinical failure cannot be rejected. The upper bound for the difference in breakage rates was 2·37%, which also exceeds the non-inferiority margin of 2% for breakage recommended in ISO 29943–1:2017. The upper bound for the difference in slippage rates was 1.41%, indicative of non-inferior clinical slippage performance for the Polyurethane B condom.

Out of the 22 Polyurethane B condoms that tore or broke, 10 (45%) were being used by men with penis lengths in the upper quartile range, i.e., longer than 170 mm. A similar trend was observed with penis girth. Of the reported 22 breakages or tears, 13 (59%) occurred when penis girth exceeded the upper quartile value of 137 mm. Although there was an overall trend of penis girth increasing with penis length, this correlation was relatively weak ($R^2 = 0.26$). Of the 70 men who reported penis lengths greater than 170 mm, however, 35 (50%) reported penis girths greater than 137 mm). Men with penis lengths exceeding 170 mm would potentially be at higher risk of breaking or tearing the Polyurethane B condom either directly due to penis length or due to girth exceeding 137 mm.

Table 9 Clinical failure rates

	PU A			PU B			Latex C		
Evaluable couples	260			258			267		
Evaluable condom uses	1221			1183			1268		
	N	%	95% CI	N	%	95% CI	N	%	95% CI
Clinical breakage	18	1.5	0.8–2.2	22	1.9	1.1–2.6	10	0.8	0.3–1.3
Clinical slippage	13	1.1	0.5–1.6	14	1.2	0.6–0.8	6	0.5	0.1–0.9
Total clinical failure	31	2.5	1.7–3.4	36	3·0	2.1–4.0	16	1.3	0.6–1.9

Quoted confidence intervals are asymptotic without continuity correction

Table 10 Clinical failure rates in published clinical studies on synthetic condoms

Study	Total clinical failures					
	Synthetic			Latex		
	N	Rate (%)	95% CI	N	Rate (%)	95% CI
Frezieres 1998–Polyurethane [5]	1025	10.8	8.9–12.7	1001	1.7	0.9–2.5
Frezieres 1999–Polyurethane [6]	1804	8.5	7.2–9.8	1882	1.6	1.1–2.2
Callahan 2000 Std–TPE [7]	1143	4.2	3.0–5.4	1166	2.0	1.2–2.8
Callahan 2000 Baggy–TPE [7]	1175	4.9	3.7–6.2	1166	2.0	1.2–2.8
Callahan 2000 Low Mod–TPE [7]	1148	4.9	3.6–6.1	1166	2.0	1.2–2.8
Cook 2001–Plastic [8]	1277	7.2	5.9–8.6	1284	1.6	0.9–2.2
Potter 2003–Polyurethane [9]	939	1.7	0.9–2.5	958	1.8	0.9–2.6

Quoted confidence intervals recalculated to match those in Table 9

Table 11 Noninferiority analyses

Condom type	PU A	Latex C	Difference (%)	2-sided 95% CI	Null hypothesis
Primary analysis: polyurethane A versus Control Latex C					
Couples	252	252	–	–	–
Condoms used	1193	1212	–	–	–
Total clinical failure (%)	28 (2.35)	16 (1.32)	1.03	(– 0.29, 2.35)	Rejected[1]
Clinical breakage (%)	15 (1.26)	10 (0.83)	0.43	(– 0.61, 1.48)	Rejected[2]
Clinical slippage (%)	13 (1.09)	6 (0.50)	0.59	(– 0.19, 1.38)	Rejected[2]
Primary analysis: polyurethane B versus control latex C					
Couples	247	247	–	–	–
Condoms used	1142	1193	–	–	–
Total clinical failure (%)	35 (3.06)	15 (1.26)	1.81	(0.39, 3.23)	Fail to Reject[1]
Clinical breakage (%)	22 (1.93)	9 (0·75)	1.17	(– 0.03, 2.37)	Fail to Reject[2]
Clinical slippage (%)	13 (1.14)	6 (0.50)	0.64	(– 0.14, 1.41)	Rejected[2]
Post Hoc analysis: polyurethane B versus latex C with male partners penis length ≤ 170 mm					
Couples	190	190			
Condoms used	886	915			
Total clinical failure (%)	20 (2.26)	11 (1.20)	1.06%	(– 0.26, 2.37)	Rejected[1]
Clinical breakage (%)	12 (1.35)	5 (0.55)	0.81%	(– 0.23, 1.84)	Rejected[2]
Clinical slippage (%)	8 (0.90)	6 (0.66)	0.25%	(– 0.57, 1.06)	Rejected[2]

[1] A non-inferiority margin of 2.5% was pre-specified for Clinical Failure in the protocol

[2] No margin was specified for Clinical Breakage or Slippage, so these outcomes are evaluated here in an exploratory fashion using a margin of 2.0% per ISO 29943–1:2017 Guidance

Since the nominal length of the Polyurethane B condom is 170 mm, the condoms would not be expected to fully cover the penises of men in the upper quartile range. This provides a relatively simple way to inform men if they are at higher risk of breaking the Polyurethane B condom. If the Polyurethane B condom does not fully cover the penis, they should use a larger condom such as Polyurethane A.

Given the significance of condoms length in determining the risk of a condom breaking, a post hoc analysis was conducted after excluding couples where the male partner's penis was longer than 170 mm. A total of 190 couples contributed to this follow-up analysis of the Polyurethane B vs Latex C condoms. The total clinical failure rate for Polyurethane B condom was 2.26% compared to 1.20% for the control latex C, which meets the non-inferiority criterion for this subset of the trial population (upper bound on the difference in rates of 2·37%).

Table 12 Discomfort by Condom Type and Gender

	Male			Female		
	PU A	PU B	Latex C	PU A	PU B	Latex C
	n = 186	n = 282	n = 171	n = 151	n = 110	n = 161
	%	%	%	%	%	%
Discomfort experienced	14	22	13[2]	12	9	12[2]
Type						
Burning	0	0	0	1	1	2[2]
Irritation	0	1	0	2	2	4
Itching	0	0	0	0	0	0
Rash	0	0	0	0	0	0
Constriction	7	14	6	NA	NA	NA
Decreased sensitivity	3	5	5	1	2	2
Dryness	2	1	1	6	4	4
Other	1	1	0	1	0	0
Severity						
Mild	6	11	7[2]	7	7	7
Moderate	7	7	4	4	24	35
Severe	2	3	1	0	2	11
Duration						
Only while wearing condom	13	20	12[2]	10	7	8[2]
1–10 min after condom removed	1	1	1	2	1	3
11–59 min after condom removed	0	0	0	0	0	1
> 59 min	0	0	0	0	0	1
Cause						
Unknown	5	5	0[2]	4	4	6
Inadequate lubrication	1	1	0	4	2	2
Rubbing, friction	0	0	0	1	1	1
Fit too tight	6	12	0	0	0	0
Fit too loose	0	0	0	0	0	0
Fit problem	0	0	0	0	0	0
Sensitivity to condom	0	0	0	0	1	0
Ring too tight	0	1	0	NA	NA	NA
Texture	0	1	0	1	1	1
Sensitivity to added lubricant	0	0	0	0	0	0
Prolonged intercourse	0	0	0	0	0	0
Unspecified condom cause	0	0	0	0	0	0
Other condom cause	0	0	0	0	0	0
Other medical problem	0	0	0	0	0	0
Other non-condom cause	0	0	0	3	0	0
Other reason	0	0	0	0	0	0

[1] Includes all subjects exposed to Study condom

[2] Chi-square statistically different: p-value < 0·05

Condom size and fit

Information about condom fit and size is included in Table 15 along with problems experienced by the users. The percentages of condoms reported being too tight during intercourse were similar for the Polyurethane A condom and control Latex C condom at 18.0% and 15.8% respectively. The difference between these rates is not statistically significant (χ^2 p-value = 0.13).

For the Polyurethane B condom, the reported rate of excessive tightness was 33% although only 22% of men reported discomfort when using this condom (Table 12).

This level of complaint is statistically significantly greater than for either Polyurethane A (χ^2 p-value < 0.001) or Latex C (χ^2 p-values < 0.001). This outcome is not surprising since Polyurethane B was designed for markets where men prefer 49 mm latex condoms and have, on average, smaller penis sizes. It also raises the question of whether the tightness of the Polyurethane B condom contributed to the failure of this condom to achieve non-inferiority with respect total clinical failure relative to the control Latex C condom in the full Study population.

Reports of discomforts and adverse events

Neither of the two serious adverse events reported by study participants nor any of the early Study discontinuations were related to condom use. Two serious adverse events were reported during the study but were not condom use related as confirmed by the independent audit of the study.

Details of discomfort reported during condom use are included in Table 12.

A total of 14% of men reported discomfort with Polyurethane A compared to 22% of men with Polyurethane B and 13% with control Latex C condoms. The main cause of discomfort was constriction, 7% of men with Polyurethane A, 14% with Polyurethane B and 6% with control Latex C. Discomfort due to constriction was statistical significantly higher for Polyurethane B than for control Latex C (chi squared p-value = 0.008). The second main cause of discomfort complaints was decreased sensitivity (3% with Polyurethane A, 5% with Polyurethane B and 5% with control Latex C). In most cases the discomfort was mild to moderate and essentially only lasted while wearing the condom.

Reports of discomfort by women followed a similar pattern with 12% reporting discomfort with Polyurethane A, 9% with Polyurethane B and 12% with control Latex C. The main cause of discomfort with women was dryness, 6% with Polyurethane A, and 4% with both the Polyurethane B and control Latex C. Again, discomfort was primarily mild to moderate and was mainly experienced while using the condoms.

Preferences and other outcomes

Subjective impressions of the condoms are summarised in Table 13.

Overall, there was very little difference in the ratings for stimulation associated with the condoms. Men rating the level of stimulation as good or excellent were 66% for Polyurethane A, 65% for Polyurethane B, and 61% for control Latex C condom. The quality of condom lubricant was rated as good or excellent by 53% of the men for Polyurethane A, 54% with Polyurethane B, and

Table 13 Subjective Impressions by Condom Type and Gender

	Male			Female		
	PU A	PU B	Latex C	PU A	PU B	Latex C
	n = 1218	n = 1182	n = 1268	n = 1268	n = 1183	n = 1265
	%	%	%	%	%	%
Stimulation during intercourse						
Excellent	20	19	19	23	22	23
Good	46	46	42	45	48	45
Fair	24	25	27	25	23	22
Poor	10	9	12	7	7	9
Condom lubricant						
Excellent	10	11	17[1]	13	13	20[1]
Good	43	43	44	37	43	40
Fair	32	32	31	33	31	28
Poor	15	13	9	17	14	12
Overall lubrication during intercourse						
Excellent	17	18	23[1]	19	20	25[1]
Good	49	48	45	46	47	41
Fair	26	27	24	26	25	26
Poor	7	7	7	9	8	9

[1] Chi-square statistically different: p-value < 0·05

Table 14 Ratings of study condoms by gender[1]

	Male			Female		
	PU A	PU B	Latex C	PU A	PU B	Latex C
	n = 266	n = 267	n = 268	n = 265	n = 267	n = 268
	Mean	Mean	Mean	Mean	Mean	Mean
Packaging worked well	6.2	6.2	6.3	6.4	6.4	6.5
Easy to put on	5.2	4.5	5.5[2,3]	5.4	4.6	5.6[3]
Pleasant or no smell	5.9	5.7	5.5[2]	6.1	6.0	5.7[2,3]
Made little or no noise	5.8	5.7	5.9	5.9	5.9	5.8
Felt soft	4.9	5.1	5.3[2]	5.3	5.3	5.4
Was comfortable	4.7	4.3	5.0[2,3]	5.0	4.9	5.1
Increased sensitivity and stimulation	3.3	3.2	3.1	3.4	3.4	3.3
I could feel my partner's body heat	4.6	4.5	4.4	4.4	4.5	4.3
I liked the amount of lubricant on the condom	4.1	4.2	4.6[2,3]	4.0	4.2	4.4[2]
I liked the way the lubricant felt	4.2	4.4	4.6[2]	4.4	4.5	4.7[2]
Lubricant on the condom lasted long enough	4.1	4.1	4.5 [2,3]	4.0	4.1	4.4 [2]
Was not messy	5.8	5.6	5.8	6.1	5.8	6.0
My overall sexual experience was good using the condom	4.9	4.6	5.0[3]	5.0	5.0	5.1
I liked as much as other condoms I've used	4.5	4.2	4.6[3]	4.6	4.6	4.9 [2,3]
Fit well	4.7	4.2	5.1[2,3]	NA	NA	NA
	4.9	4.7	5.0	5.0	5.0	5.1

[1] Scale of 1–7 where "1" indicates "strongly disagree" and "7" indicates "strongly agree"

[2] Polyurethane A condom and Latex C condom significantly different (p-value < = 0·05)

[3] Polyurethane B condom and Latex C condom significantly different (p-value < = 0·05)

61% with control Latex C. The ratings by women were very similar. Both men and women reported statistically higher percentages of excellent ratings for the latex condom lubricant compared to the polyurethane condom lubricant.

Acceptability ratings are summarised in Table 14 using a scale of 1–7 where "1" indicates strong disagreement and "7" indicates strong agreement.

The mean ratings by men were 4.9 for Polyurethane A, 4.7 for Polyurethane B, and 5.0 for control Latex C. The ratings by women were similar to those of the men with scores of 5.0, 5.0 and 5.1 respectively for the condoms.

Problems associated with condom use are reported in Table 15.

Putting the condoms on was reported to be difficult with 25.9% uses of Polyurethane A, 42.3% uses of Polyurethane B, and 22.1% uses of control Latex C. The smaller size of Polyurethane B was the likely cause of the higher rate of difficulty associated with donning this condom. Unrolling Polyurethane B condom was difficult in 20.0% of uses compared to 14.0% of Polyurethane A uses and 11·1% of Latex C uses.

Overall, Polyurethane A was similar to Latex C in terms of acceptability, lubrication, and other characteristics whereas the smaller Polyurethane B condom was more difficult to put on, uncomfortable and regarded as too tight by a larger percentage of men. Despite these issues, Polyurethane B was reported in Table 16 to be liked for sensation by 56% of men who preferred Polyurethane B compared to 43% of men who preferred Polyurethane A and 34% who preferred control Latex C. Women who preferred Polyurethane B were more likely to cite sensation (45% for Polyurethane B, 27% for Polyurethane A and 30% for control Latex C).

Discussion

As detailed in Table 11. A total of 252 couples contributed 2405 evaluable condom uses for the non-inferiority comparison of Polyurethane A versus control Latex C condoms. The respective total clinical failure rates were 2.35 and 1.32%, resulting in a difference of 1·03% with a one-sided 97.5% upper bound of 2.35%. Since this upper bound is less than the 2.5% non-inferiority margin specified in ISO 23409:2011, it can be concluded that the total clinical failure rate for the ultra-thin Polyurethane A condom is non-inferior to the rate for thin control Latex C condom.

In terms of ease of use, acceptability and comfort, Polyurethane A condoms performed similarly to Latex C condoms although both men and women reported

Table 15 Occurrence of problems by condom type

	PU A %	PU B %	Latex C %
Donning attempted	n = 1304	n = 1306	n = 1321
Difficulty putting condom on[1]	25.9	42.3	22.1
Tried to put condom on backwards	2.2	2.0	1.9
Trouble unrolling condom	14.0	20.0	11.1
Condom too tight	9.4	19.5	8.4
Other problem	0.4	0.8	0.7
Used for vaginal intercourse	n = 1221[2]	n = 1882[2]	n = 1268[2]
Condom too tight during intercourse[1]	18.0	33.0	15.8
Condom too loose during intercourse[1]	4.4	1.5	3.4
Slippage along penis during intercourse	10.8	9.8	9.7
Slip off penis during intercourse	1.1	1.2	0.5
Slip off penis during withdrawal	2.2	2.9	1.4
Condom stretching	3.1	4.3	3.2
Bunching	7.7	7.6	7.6
Leaking from open end of condom[1]	3.5	3.3	2.0
Tear during donning	0.0	0.2	0.3
Tear during intercourse	1.5	1.8	0.9
Male discomfort[1]	1.4	20.0	12.7
Female discomfort[1]	12.1	9.2	11.9

[1] Chi-square statistically significant: p-value < ·0.05

[2] Denominator varies slightly for some variables due to missing information

slightly higher overall score rating for the Latex C condom than for Polyurethane A. Forty-three percent (43%) of men who preferred Polyurethane A cited sensitivity as the reason for their preference compared to 34% of men who preferred control Latex C.

A total of 247 couples contributed 2,335 evaluable condom uses for the non-inferiority comparison of Polyurethane B versus control Latex C condoms. The respective total clinical failure rates were 3.06 and 1.26%, resulting in a difference of 1.81% with a one-sided 97.5% upper bound of 3.23%, leading to the conclusion that the null hypothesis that Polyurethane B is inferior to Latex C with respect to clinical failure cannot be rejected.

The smaller Polyurethane B condom was designed for use in populations where men on average have smaller penis sizes and prefer the 49 mm latex condom. Restricting the Study population for Polyurethane B to reflect the intended user population was not considered feasible when planning the Study, especially considering the restrictions imposed on the Study due to Covid 19. Instead, as reflected in the protocol, it was decided to evaluate whether there was an association between penis size and clinical failure rate for each condom type based on the Study results. In the case of Polyurethane B, 10 out of the 22 breakages (45%) occurred when the condom was used by men in the upper quartile range for penis length. The start of the upper quartile range for the penis length of the Study population was 170 mm which is also the specified nominal length of the Polyurethane B condom.

The non-inferiority analysis of Polyurethane B versus control Latex C was therefore repeated for the subset of 190 couples with male partner penis length ≤ 170 mm. In this subset of the Study population, the clinical failure rates were 2.26% for Polyurethane B and 1.20% for control Latex B, a difference of 1.06% with upper 97.5% confidence interval bound of 2·37%, which meets the non-inferiority criterion of < 2·5%.

Since the Polyurethane B condom might not fully cover the penises of men in the upper quartile range, the instructions for use should include advice to not use the condom if it does not fully cover the penis. In conclusion, therefore, the Polyurethane B condom is non-inferior to the control Latex C when used by men with smaller penises allowing the condom to completely cover the penis.

This post hoc analysis highlights the importance of matching condom size to penis size, not just for comfort but also to ensure the effectiveness of the condom. There are clear implications for drafting the instructions of use provided by manufacturers and guidelines on condom uses provided by reproductive health professionals.

It should also be noted that the thin control Latex C condom also performed extremely well in the Study. Clinical breakage and slippage results compared favourably with the rates reported in the previously published studies reported in Table 10 for conventional thickness NR latex condoms.

The Study population, which was socially and ethnically diverse, was as typical of regular condom users as possible given the constraint that alternative methods of contraception had to be used to guard against unwanted pregnancies. All participants had previously used condoms although 43% had not used condoms within the year prior to the study. The crossover design and large size of the study minimised any risk of bias. Standard definitions of failure modes were used as specified in ISO 29943–1:2017 and these were illustrated and explained clearly by video to all participants. Although results were self-reported, the report and feedback forms were designed to reduce the risk of inconsistent answers. Participants were required to return any failed condoms to deter false claims of failure. The requirement for participants to use backup methods of contraception led to a certain amount of risk behaviour such as starting intercourse without putting the condom on first (9% of uses) and removing the condom prior to ejaculation (13%

Table 16 What participants liked about their preferred study condom by gender

	Male			Female		
	PU A	PU B	Latex C	PU A	PU B	Latex C
	n = 69	n = 62	n = 92	n = 71	n = 58	n = 86
	%	%	%	%	%	%
What participants liked[1]						
Sensation	43	56	34	27	45	30
Appearance	3	2	3	6	5	1
Scent	1	2	2	6	2	3
Lubricant on condom	12	16	12	17	19	29
Amount of lubricant on condom	13	15	14	24	24	17
Feel of lubricant on condom	0	3	2	0	0	3
Condom package	0	2	0	1	0	1
Ease of donning	12	6	26	13	7	10
Thinness of condom material	16	18	7	25	17	7
Way condom fit	38	27	43	4	3	7
Tightness of condom fit	3	3	0	0	0	0
Looseness of condom fit	0	0	1	0	0	0
Condom stayed in place	6	8	4	0	0	5
Comfortable	10	13	14	11	22	12
Texture of condom material	10	5	4	10	5	13
Lack of noise	1	0	1	1	7	5
Softness	1	2	1	0	0	0
Not messy	0	3	3	4	3	0
Prolongs sex	0	0	0	0	2	2
Easy to use	9	3	2	1	2	3
Transfers body heat	4	6	2	3	12	5
Different	0	0	1	0	0	0
Dependable	4	2	4	3	2	1
Protection	0	0	1	0	0	1
No leakage	1	0	0	0	0	0
Partner liked	1	5	2	21	7	23
No side effects	0	0	1	6	2	3
Liked Study condom	3	0	3	3	0	2
Unique condom attribute	4	2	7	6	9	6

[1] Multiple responses permitted

of uses). In practice therefore when condoms are being used for protection, clinical failure rates may be lower.

Conclusions

This study has demonstrated that the Sagami Polyurethane A condom is non-inferior to the control Latex C condom used in this study. The one-sided 97·5% upper bound of the difference in total clinical failure rates relative to the latex control condom was 2.35%, which is less that the limit of 2.5% specified in ISO 29943–1:2017.

Although Sagami Polyurethane B condoms did not meet the non-inferiority criterion relative to control Latex C condom when used by the total trial population, it did meet the noninferiority requirement when used by men with penis lengths shorter than 170 mm with the 97.5% upper bound of the difference in total clinical failure rates of 2.37%. This condom is therefore suitable for men with smaller penises.

Abbreviations

NR	Natural rubber
PU	Polyurethane
STI	Sexually transmitted infection
HIV	Human immunodeficiency virus
AIDS	Acquired immunodeficiency syndrome
FDA	Food and Drug Administration
ISO	International Standards Organization
GEE	Generalized estimating equations
EAH	Essential Access Health
IRB	Institutional review board

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W DP: Writing—original draft—review and editing. G R B: Writing—review and editing. T R W: Review and editing. All authors reviewed the manuscript and have approved its submission for publication.

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Availability of data and materials
The protocol, statistical analysis plan, and summary results including participants flow, baseline characteristics, outcome measures, and adverse event details are published on ClinicITrials.gov, NCT04622306. Requests submitted to the Corresponding Author to share the dataset used for the noninferiority analysis will be considered by the Authors on a case by case basis.

Declarations

Competing interests
Terri Walsh, Lead Investigator has no conflicts of interests to declare. Grant Burt, Sagami Europe SAS was appointed as Study Director by Sagami Rubber Industries Co., Ltd. William Potter was contracted as a consultant by Sagami Rubber Industries Co., Ltd., Japan, to act as the Clinical Director for the study.

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