ARTICLE

Check for updates

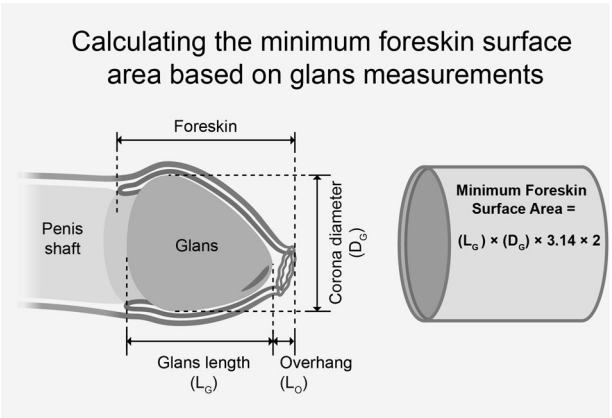
Calculating foreskin surface area based on glans measurements of 143 men using a simplified geometrical model of the foreskin

Guido Hegazy[1,3]✉, Manasseh Seidenberg[1,3], Holger Erb[2] and Joerg Syllwasschy[2]

Dimensions of male genitalia have received considerable scientific attention, but the foreskin has been largely omitted from these efforts. To calculate the foreskin surface area based on measurements of patients or voluntary study participants, we describe the foreskin in a simplified model as a tube of elastic tissue with a minimum length corresponding to that of the glans, and a minimum diameter corresponding to that of the corona in flaccid or erect state. To apply our model, we re-analysed previously collected data from a study of penile measurements. In this study from 2001, genitalia of 143 men aged 18 – 68 were measured in flaccid and erect state. Participants were recruited from secondary schools and hospitals, and penile measurements were performed once on a single day by a single medical doctor. We used this set of data to calculate the foreskin surface area and added 10% to the raw glans measurements to account for functional tissue elasticity. We found a median surface area of 79.8 cm^2 (Q1 = 63.8 cm^2, Q3 = 86.6 cm^2) and a mean foreskin surface area of 76.2 cm^2 ± 18.9 cm^2 (Range 37.6 cm^2 – 136.8 cm^2). We assume that our approximation is rather an underestimation as we did not include the frenulum and foreskin overhang in our calculation. Our re-evaluation of data from an earlier descriptive study using a simplified geometrical model allows an estimation of foreskin surface area, e.g. as a tissue source for reconstructive surgeries. In summary, we present an estimated reference value of 80 cm^2 (rounded median value) and a simple calculation model for the male foreskin surface area.

IJIR: Your Sexual Medicine Journal; https://doi.org/10.1038/s41443-026-01255-2

Graphical Abstract



INTRODUCTION

Average dimensions of male genitalia have repeatedly been the subject of scientific attention [1], but one part of the penis has been largely ignored by these efforts: the foreskin. We considered estimating the average foreskin size a relevant contribution for several reasons: 1. It is remarkable that the penis has been measured with such intense scientific interest [2–12], but very few data are available on the size of the foreskin [13, 14]. 2. The foreskin has been used as a tissue source for reconstructive surgeries, e.g. as skin grafts in the treatment of burn wound

[1]ARGUS-Kinderschutz c/o IP-Man.39427, Ludwig-Erhard-Straße 18, 20459 Hamburg, Germany. [2]pro familia Landesverband NRW e.V., Kolpingstrasse 14, 42103 Wuppertal, Germany. [3]These authors contributed equally: Guido Hegazy, Manasseh Seidenberg. ✉email: doc@argus-kinderschutz.org

Received: 1 June 2025 Revised: 21 February 2026 Accepted: 11 March 2026
Published online: 30 March 2026

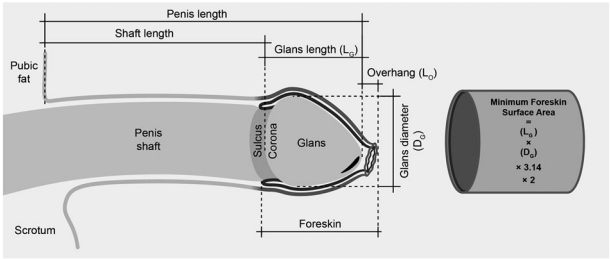


Fig. 1 Measurements of the penis and calculation model for the foreskin surface area.

repairs [15], vaginoplasty [16, 17], syndactyly [18] and hypospadias reconstructions [19, 20]. Still, no method has been described that allows surgeons to estimate the amount of tissue available from these skin grafting techniques in preoperative planning, either for an individual patient or on average. 3. The foreskin surface area has been correlated with the risk of HIV transmission [13], but no reference value on the average size of this surface exists. These reasons prompted us to develop a simplified geometrical model for calculating the average size of the foreskin based on glans measurements.

To apply our model, we made use of an existing set of data from an earlier study that was initiated in 2001 by us at pro familia, Germany's leading non-governmental organization for counseling on sexuality and partnership [2]. In this study, penile dimensions were measured in 143 men in flaccid and erect state, but data on measurements of the glans were only partially published. Since these unpublished data were still available to us for calculation, we made use of the results from the 2001 pro familia study. The aim of our study was to apply our simplified geometrical model to re-evaluate previously collected data on penile dimensions and give a first estimate value for the average surface area of the male foreskin.

METHODS

To calculate the foreskin surface, we assumed the following properties: 1. The foreskin is defined by its ability to cover the glans, and thus its minimum length is that of the glans. Foreskins that are longer or shorter than the glans will cancel each other out when calculating mean and median values. 2. The minimum physiological diameter of the foreskin is that of the corona, as this rim is easily passed any time the foreskin is pulled back and forth. 3. Both measurements are valid for the erect penis as well, since the movement of the foreskin over the erect glans is a physiological feature and pleasurable during masturbation and sexual intercourse. 4. The foreskin consists of an outer and inner layer that are movable relative to each other, therefore the foreskin surface area comprises both surfaces. 5. The elasticity of the tissue is an essential feature of the foreskin that allows it to perform its physiological movement. Thus, we hypothesized that the minimum foreskin surface area can be estimated by calculating a tube of elastic tissue with the measurements of the coronal diameter and the glans length in flaccid or erect state.

The pro familia study participants have been described in detail before [2]. The Urology Department of the University Hospital of Essen, Germany, recruited 143 adult men for this study to measure penile dimensions in flaccid and erect state. In the original study, two groups were formed. Group A, termed "younger men", were recruited by advertising for four weeks in secondary schools (111 participants). Group B, termed "older men", were recruited at the Urology Department of the University Hospital of Essen, where men were seeking advice for erectile dysfunction (32 participants). Age range was 18 – 68 years (group A 18 – 19 years, group B 40 – 68 years). Exclusion criteria were insufficient erection, a history of radical prostatectomy or urethral surgery, or Peyronie's disease. A history of circumcision was neither recorded nor an exclusion criterion for participation in the original study. Since the corona diameter was measured in both flaccid and erect states with the foreskin retracted, presence or abscence of a foreskin did not influence measurement results of the glans in the study. No further demographic data (e.g. marital status) or medical data (e.g. smoking habits, comorbidities) were recorded in the original study.

All participants signed a declaration of informed consent for taking measurements of their penis in flaccid and erect state, and the use of these data for scientific evaluation by pro familia without a time limit for analysis or publication. No re-identification of participants was possible. The study design was reviewed by the Ethics Committee of the University of Essen, Germany, and use of these data for calculating glans dimensions in the present work was covered by the approval (99-191-1322-Y). Erection was achieved either by self-stimulation for healthy individuals or during diagnostic prostaglandin E1 injection in individuals seeking advice for erectile dysfunction. All measurements in flaccid and erect state were carried out by a single medical doctor to eliminate inter-observer bias. All measurements were taken on a single day to reduce intra-observer bias, although this was not formally tested in the original study. All length measurements were taken using a ruler and applying slight pressure on the prepubic fat against the pubic bone, similar to the method used by Söylemez et al.[11]. Although the measurement protocol did not specify any increments, length measurements of the penis were recorded in 5 mm steps. Measuring in 5 mm increments is common in studies analyzing penis length [4, 7], although this may lead to a possible rounding bias. The diameter measurements were taken using a caliper similar to the method used by Chen et al.[12].

Glans lengths were calculated as penis length minus shaft length for flaccid or erect state, respectively. If a shorter glans length or a shorter diameter was measured for the erect state (rather than for the flaccid state), the value for the flaccid state was used for calculation. Surface area was calculated as a cylinder according to the suggested model and formula (Glans length) × (Corona diameter) × Pi × 2 as shown in Fig. 1. We calculated the average surface area based on raw measurements of the glans. We then added 10% in a second calculation to account for physiological elasticity of foreskin tissue. We chose this low correction factor of 10% based on a study by Rupani et al.[21], finding skin stretchability greater than 10% throughout all body regions analyzed, and a study by Mosa et al.[19] finding 38% stretchability of foreskin tissue. As further discussed in the Discussion section, no accepted value for foreskin stretchability exists, and thus this adjustment is considered an arbitrary estimate rather than a physiological constant.

The results of our calculations were plotted as histograms to visually confirm a bell-shaped distribution of the values. Data normality was tested with the Kolmogorov-Smirnov test ($\alpha = 0.05$) for each group, and group means were compared using the t-test. Calculations were done in MS Excel and using the Real Statistics Resource Pack. We also report median values rounded to the nearest whole number in addition to the primary calculation results, in order to take into account the simplicity of our model in conjunction with the measurement technique that was employed in the original study.

RESULTS

We analyzed normality of calculated foreskin surface areas for each group defined in the original study (Group A: $n = 111$; Group B: $n = 32$) using the Kolmogorov-Smirnov test, which showed no significant deviation from normality in both groups (Group A: $D = 0.115$, $p = 0.997$; Group B: $D = 0.101$, $p = 0.868$). Group means did not differ significantly (Group A: 63.1 $cm^2 \pm 16.2$ cm^2; Group B: 62.4 $cm^2 \pm 13.9$ cm^2; t-test $p = 0.81$). The pooled data ($n = 143$) also followed a normal distribution ($D = 0.094$, $p = 0.152$), justifying combined analysis. When calculations were performed using raw glans measurements of all study participants, we found a median surface area of 65.9 cm^2 ($Q1 = 52.7$ cm^2, $Q3 = 71.6$ cm^2) and a mean surface area of 62.9 $cm^2 \pm 15.6$ cm^2 (range 31.1 cm^2 – 113.1 cm^2). We report both median and mean values, prioritizing the median to minimize the influence of outliers. When adding 10% to the raw glans measurements, we obtained a median surface area of 79.8 cm^2 ($Q1 = 63.8$ cm^2, $Q3 = 86.6$ cm^2) and a mean surface area of 76.2 $cm^2 \pm 18.9$ cm^2 (range 37.6 cm^2 – 136.8 cm^2). Frequencies plotted in 10 cm^2 bins formed a bell-shaped curve resembling a gaussian distribution as shown in Fig. 2. The kurtosis was 0.85 and the skewness was 0.56. All results are summarized in Table 1.

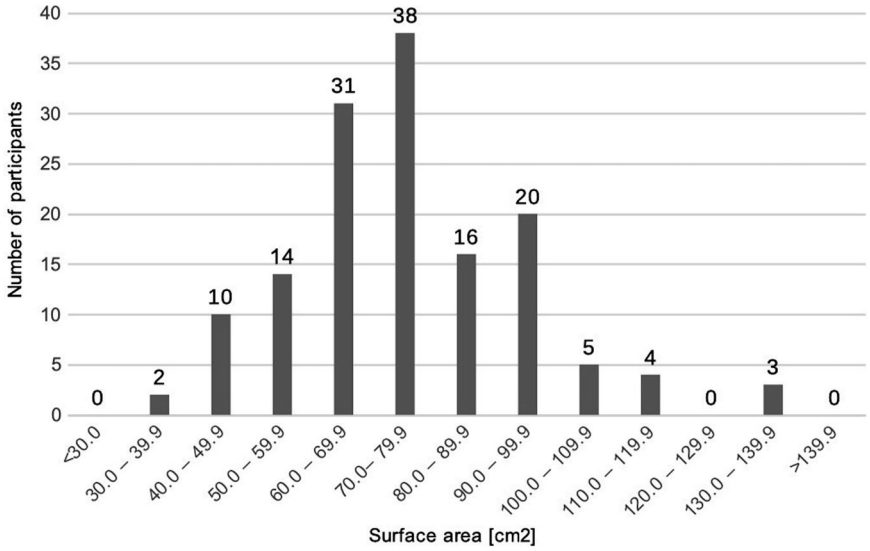


Fig. 2 Distribution of calculated foreskin surface areas.

Table 1. Measurements of the glans in flaccid and erect state, and calculation results of foreskin surface area according to the model.

	Median	Q1	Q3	Mean	SD	Min	Max
Glans length in flaccid state	2.0 cm	2.0 cm	2.5 cm	2.2 cm	±0.6 cm	1.0 cm	4.0 cm
Glans length in erect state	3.0 cm	2.5 cm	3.0 cm	2.8 cm	±0.6 cm	1.5 cm	4.5 cm
Glans diameter in flaccid state	3.0 cm	2.8 cm	3.3 cm	3.0 cm	±0.4 cm	2.2 cm	3.7 cm
Glans diameter in erect state	3.5 cm	3.2 cm	3.6 cm	3.5 cm	±0.4 cm	2.5 cm	4.5 cm
Calculated surface area (raw values)	65.9 cm^2	52.7 cm^2	71.6 cm^2	62.9 cm^2	±15.6 cm^2	31.1 cm^2	113.1 cm^2
Calculated surface area (+ 10%)	79.8 cm^2	63.8 cm^2	86.6 cm^2	76.2 cm^2	±18.9 cm^2	37.6 cm^2	136.8 cm^2

DISCUSSION

In this study we suggest a simplified model for calculating the foreskin dimensions in individual patients or study participants. We propose a model of the foreskin as a functional tube of elastic tissue, with the diameter measuring at least the diameter of the corona, and length measuring at least the length of the glans.

The calculation of the foreskin as a tube can be considered an overly simplified model, but we considered this approach justified due to the foreskin's mobility over the glans and its physiological elasticity. In addition, the foreskin can be regarded as physiologically forming a tubular structure when it is retracted behind the glans and encloses the cylinder of the penis shaft in erect state. Furthermore, our model allows estimating a patient's foreskin size without the need for specialized technical equipment.

We used existing data of 143 men from a previous study without applying a new statistical design or collecting new data. This allowed us to directly test our calculation, saving us time and resources. Besides using raw measurements, we also calculated the surface area adding 10% to the raw measurement of the glans diameter and length to account for physiological tissue elasticity. In absolute numbers, this meant an average addition of 3.5 mm to the diameter and 2.9 mm to the length of the glans. In this calculation, we found a median surface area of 79.8 cm^2. We compared our results with Kigozi et al. and Werker et al.[13, 14], two publications frequently cited on foreskin dimensions. Kigozi et al. analyzed resectates from 965 circumcision surgeries and found a median surface area of the resectates of 35 cm^2 with a range from 7 cm^2 to 99 cm^2. Werker et al. analyzed 8 cadaveric and two vital specimens for their feasibility as flap grafts in reconstructive surgery and found a surface area range of 18 cm^2 to 90 cm^2. In these studies, the surgery was carried out for other reasons than analyzing an anatomical dimension. These results are likely influenced by several factors, e.g. the intended surgical results, the surgical technique employed, and the surgical devices used. Therefore, we assume that measurements on surgical resectates taken for other reasons than anatomical analyses do not necessarily reflect a physiological parameter. Furthermore, in the publication by Kigozi et al., the authors did not state whether the term "surface area" referred to both the inner and outer surface or only to the inner side of the foreskin. Considering the aim of the study, the latter one is likely the case, and thus values stated in this publication would have to be multiplied by two to be comparable to our results.

In our calculation, we also added 10% to the raw glans measurements to account for elasticity of the foreskin. To our knowledge, no reference values exist on the average physiological stretchability of foreskin tissue. In a study by Mosa et al.[19], a comparison of unstretched and stretched foreskin resulted in a mean increase of approximately 38%. In a study by Rupani et al.[21], physiological skin stretch was greater than 10% throughout all body regions analyzed. Thus, we assume that our addition of 10% to the raw glans measurements is rather a conservative estimate, and that the functional foreskin surface area might be substantially higher. Still, one can argue that in the absence of an accepted reference value for foreskin stretchability, choosing any specific percentage is an arbitrary decision.

In a review of the literature, we found 11 publications regularly cited for male genitalia measurements [2–12]. Among these, only the publication by Chen et al. presents glans measurements in erect state [12]. Applying our calculation model to the data of Chen et al., we calculate a mean surface area of 72.6 cm^2 with a range of 47.5 cm^2 to 135.8 cm^2 and when adding 10% to the raw data a mean surface area of 87.8 cm^2 with a range of 57.4 cm^2 to 164.3 cm^2. We speculate that the higher results in the study by Chen et al. may be attributed to a

different measuring technique rather than a difference in the ethnicity of the study participants [22].

We consider our calculation to be rather an underestimation for the following reasons: 1. The frenulum is an internal part of the foreskin that is intensely folded, but none of this extra surface is incorporated in our calculation. 2. The foreskin can extend considerably beyond the glans at the site of the meatus, a part that was referred to in ancient Greek as the acroposthion, while the Terminologia Anatomica offers no term for it [23]. None of this extra foreskin overhang is included in our calculation. 3. We could not include the sulcus proximal to the corona in our calculation although the mucosal lining of the sulcus belongs to the foreskin as well (Fig. 1). A factor that might influence our calculation in both directions is the fact that the corona of the glans is not perfectly circular. Still we assume that this difference does not cause a relevant change in the results.

A limitation of our primary data is the fact that 98% of the length measurements of the penis were recorded in 5 mm steps, potentially introducing a rounding bias. However, this is in line with other studies that recorded penile length measurements in 5 mm increments as part of their study design [4, 7]. Another limitation of the primary data is that measurements were taken by a single physician to reduce inter-observer variability, but intra-observer reliability was not formally tested.

Devices and techniques for measuring penile dimensions vary between different studies, making comparisons of results difficult [24]. To analyze penis circumference, some authors used a caliper [12], some used a ruler [11], and some used a tape measure [5, 7–9]. According to our experience with the pro familia study data, we suggest that future glans measurements use a tape measure for length and corona circumference, which would also take the non-circular shape of the corona into account.

CONCLUSION

We describe the foreskin as an elastic tubular structure with a median surface area of about 80 cm^2 in our study group. We propose a simplified method to estimate its surface area using easily obtainable glans measurements. This estimation can support preoperative planning for reconstructive surgeries involving foreskin as a tissue source. Further studies with larger groups are needed to confirm our findings and improve understanding of average anatomical dimensions of the foreskin, an often overlooked part of male genitalia.

DATA AVAILABILITY

The data used in this study are available upon request from the authors.

REFERENCES

1. Falcone M, Bettocchi C, Carvalho J, Ricou M, Boeri L, Capogrosso P, et al. European Association of Urology Guidelines on Penile Size Abnormalities and Dysmorphophobia: Summary of the 2023 Guidelines. Eur Urol Focus. 2024;10:432–41.
2. Schneider T, Sperling H, Lümmen G, Syllwasschy J, Rübben H. Does penile size in younger men cause problems in condom use? A prospective measurement of penile dimensions in 111 young and 32 older men. Urology. 2001;57:314–8.
3. Chen J, Gefen A, Greenstein A, Matzkin H, Elad D. Predicting penile size during erection. Int J Impot Res. 2000;12:328–33.
4. Ponchietti R, Mondaini N, Bonafè M, Di Loro F, Biscioni S, Masieri L. Penile Length and Circumference: A Study on 3,300 Young Italian Males. Eur Urol. 2001;39:183–6.
5. Spyropoulos E, Borousas D, Mavrikos S, Dellis A, Bourounis M, Athanasiadis S. Size of external genital organs and somatometric parameters among physically normal men younger than 40 years old. Urology. 2002;60:485–9.
6. Son H, Lee H, Huh J-S, Kim SW, Paick J-S. Studies on self-esteem of penile size in young Korean military men. Asian J Androl. 2003;5:185–9.
7. Awwad Z, Abu-Hijleh M, Basri S, Shegam N, Murshidi M, Ajlouni K. Penile measurements in normal adult Jordanians and in patients with erectile dysfunction. Int J Impot Res. 2005;17:191–5.
8. Mehraban D, Salehi M, Zayeri F. Penile size and somatometric parameters among Iranian normal adult men. Int J Impot Res. 2007;19:303–9.
9. Promodu K, Shanmughadas KV, Bhat S, Nair KR. Penile length and circumference: an Indian study. Int J Impot Res. 2007;19:558–63.
10. Khan S, Somani B, Lam W, Donat R. Establishing a reference range for penile length in Caucasian British men: a prospective study of 609 men. BJU Int. 2012;109:740–4.
11. Söylemez H, Atar M, Sancaktutar AA, Penbegül N, Bozkurt Y, Önem K. Relationship between penile size and somatometric parameters in 2276 healthy young men. Int J Impot Res. 2012;24:126–9.
12. Chen XB, Li RX, Yang HN, Dai JC. A comprehensive, prospective study of penile dimensions in Chinese men of multiple ethnicities. Int J Impot Res. 2014;26:172–6.
13. Kigozi G, Wawer M, Ssettuba A, Kagaayi J, Nalugoda F, Watya S, et al. Foreskin surface area and HIV acquisition in Rakai, Uganda (size matters). AIDS. 2009;23:2209–13.
14. Werker PM, Terng AS, Kon M. The prepuce free flap: dissection feasibility study and clinical application of a super-thin new flap. Plast Reconstr Surg. 1998;102:1075–82.
15. Zaroo M, Sheikh B, Wani A, Darzi M, Mir M, Dar H, et al. Use of preputial skin for coverage of post-burn contractures of fingers in children. Indian J Plast Surg. 2011;44:68.
16. Acimi S. Vaginoplasty using the inner surface or mucosa of the prepuce in children with congenital adrenal hyperplasia. J Pediatr Urol. 2013;9:1038–42.
17. Opsomer D, Gast KM, Ramaut L, De Wolf E, Claes K, Sommeling C, et al. Creation of Clitoral Hood and Labia Minora in Penile Inversion Vaginoplasty in Circumcised and Uncircumcised Transwomen. Plast Reconstr Surg. 2018;142:729e–733e.
18. Ehrlichman RJ, Driscoll DN, Cornejo K, Upton J. Preputial Grafts: The Forgotten Donor Site. Ann Plast Surg. 2018;81:657–61.
19. Mosa H, Olczak B, Paul A, Mishra P, Taghizadeh A, Garriboli M. Are there anatomical limiting factors to foreskin reconstruction at the time of single-stage hypospadias repair? J Pediatr Urol. 2023;19:700.e1–700.e10.
20. Sedberry-Ross S, Stisser BC, Henderson CG, Rushton HG, Belman AB. Split Prepuce In Situ Onlay Hypospadias Repair: 17 Years of Experience. J Urol. 2007;178:1663–7.
21. Rupani M, Cleland LD, Saal HP. Local postural changes elicit extensive and diverse skin stretch around joints, on the trunk and the face. J R Soc Interface. 2025;22:20240794.
22. Mostafaei H, Mori K, Katayama S, Quhal F, Pradere B, Yanagisawa T, et al. A Systematic Review and Meta-Analysis of Penis Length and Circumference According to WHO Regions: Who has the Biggest One? Urol Res Pract. 2025;50:291–301.
23. FIPAT Federative International Programme for Anatomical Terminology. *Terminologia Anatomica*. 2nd ed. 2019.
24. Greenstein A, Dekalo S, Chen J. Penile size in adult men—recommendations for clinical and research measurements. Int J Impot Res. 2020;32:153–8.

ACKNOWLEDGEMENTS

The authors would like to thank Jason Metters and Ephraim Seidenberg for proofreading of the manuscript.

AUTHOR CONTRIBUTIONS

GH: Conceptualization, Formal analysis, Writing - Original Draft, Visualization, Supervision. MS: Investigation, Methodology, Validation, Writing - Review & Editing. HE: Investigation, Formal analysis, Project administration, Data Curation, Writing - Review & Editing. JS: Conceptualization, Investigation, Project administration, Data Curation, Writing - Review & Editing.

FUNDING

The authors received no financial support for this study.

COMPETING INTERESTS

The authors declare no competing interests.

ETHICS APPROVAL AND CONSENT

The study was performed in line with the principles of the 1964 Declaration of Helsinki. Privacy rights of human subjects have been observed and informed consent was obtained from all volunteers. The study was performed in compliance with

relevant laws and institutional guidelines and has been approved by the Ethics Committee of the Medical Faculty of the University of Essen, Germany.

ADDITIONAL INFORMATION

Correspondence and requests for materials should be addressed to Guido Hegazy.

Reprints and permission information is available at http://www.nature.com/reprints

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.