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Caesarean section in Palestine using the Robson Ten Group Classification System: a population based birth cohort study

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Abstract

Objective To analyze the current situation of caesarean section in Palestine using the Robson Ten Group Classification System (TGCS).

Design A population-based birth cohort study.

Setting Obstetric departments in three governmental hospitals in Gaza.

Participants All women who delivered between 1 January 2016 and 30 April 2017 were included.

Methods The contributions of each group to the study population and to the overall rate of caesarean section were calculated, as well as the rate of caesarean section in each TGCS group. Differences in proportions between study hospitals were assessed by $\chi 2$ test.

Main outcome measures The main outcome was the contributions of each group to the overall caesarean section rate.

Results The overall rate of caesarean section was 22.9% (4337 of 18 908 deliveries), ranging from 20.6% in Hospital 1 to 24.6% in Hospital 3. The largest contributors to the overall caesarean section rate were multiparous women with single cephalic full-term pregnancy who had undergone at least one caesarean section (Group 5, 42.6%), women with multiple pregnancies (Group 8, 11.6%) and those with single cephalic preterm labour (Group 10, 8.1%). Statistically significant differences in caesarean section rates between the study hospitals were observed in Group 1 (nulliparous women with single cephalic full-term pregnancy and spontaneous labour), Group 4 (multiparous with single cephalic full-term pregnancy with induced labour or prelabour caesarean section), Group 5 (multiparous with single cephalic full-term pregnancy with previous caesarean section) and in Group 7 (multiparous with breech presentation).

CONCLUSION Women in Groups 5, 8 and 10 were the largest contributors to the overall caesarean section rate in the study hospitals. Efforts to reduce the differences in obstetric care between hospitals need to be directed towards increasing the proportion of vaginal births after caesarean section and by reducing primary caesarean section in multiple pregnancies and preterm labour.

Strength and limitation of the study

- This study is the largest, population-based, prospective birth cohort study in Palestine.
- It was the first to explore caesarean section rates in Palestine using the Robson Ten Group Classification System.
- All women who gave birth in the study hospitals were included, reducing the risk for selection bias.
- The main limitation of this study was the fact that the women, delivering in the West Bank or in the private sector in Gaza, were not included.

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Introduction:

Globally, caesarean section rate is rising continuously, making caesarean section one of the commonest surgical procedures.[1] One in five pregnant women undergoes caesarean section.[1] The caesarean section rate is often used as an indicator for the quality of healthcare, and may therefore reflect improvement of clinical governance at national and international level. However, caesarean section rates vary between countries and even between hospitals within the same country.[1-3] The World Health Organization (WHO) recommends caesarean section rates to be between 10–15%.[4] In order to investigate the underlying mechanisms for the global rise in caesarean section rates, it is fundamental to identify which groups of women are at higher risk to undergo caesarean section. For this reason, a classification system that can monitor and compare caesarean section rates in a standardized, reliable and consistent manner has been established.[5] The International Federation of Gynecology and Obstetrics (FIGO) and WHO recommend the Robson Ten Group Classification System (TGCS) as a global standard for assessing, monitoring and comparing caesarean section rates between countries and institutions.[6-8] The TGCS classifies women into 10 groups according to five obstetric characteristics that are routinely documented and easy to implement (table 1).[5] By applying TGCS, caesarean section births are being registered in relation to the women's and pregnancies' characteristics rather than medical indications.[5 6]

Table 1 The Robson Ten Group Classification System

Group	Description
1	Nulliparous, singleton, cephalic, full-term, spontaneous labour
2	Nulliparous, singleton, cephalic, full-term, induced labour or prelabour caesarean section
3	Multiparous, singleton, cephalic, full-term, without a previous caesarean section, spontaneous labour
4	Multiparous, singleton, cephalic, full-term, without a previous uterine scar, induced labour or prelabour caesarean section
5	Multiparous, singleton, cephalic, full-term, with a previous caesarean section

6	Nulliparous, singleton, breech
7	Multiparous, singleton, breech
8	Multiple pregnancy (twins or higher-order multiples)
9	Singleton, transverse or oblique lie
10	Singleton, cephalic, preterm

In Palestine, no hospital has used the TGCS so far. The objective of this study was to analyze the current situation with the use of caesarean section according to TGCS, and to identify the main contributors to the rate of caesarean section in three hospitals in Gaza.

Methods:

Study design and participants

The data were obtained from a population-based birth cohort study in three Palestinian governmental hospitals in Gaza from 1 January 2016 until 30 April 2017. Two of the hospitals were teaching hospitals (Hospitals 2 and 3). Teaching hospitals in Palestine have educational programs for health personnel; such as medical doctors, midwives and nurses. Two of the hospitals were referral hospitals (Hospitals 1 and 3). Referral hospitals in Palestine receive patients from other private or governmental hospitals in the neighbouring areas. Hospital 2, being non-referral, was the only one without a maternal intensive care unit. All women, who delivered in the study hospitals during the study period, were eligible for inclusion. Cases with unknown method of delivery (n=373) or cases with missing information on one or more of the following variables: parity, presentation, gestational age or previous caesarean section (n=3) were excluded (figure 1).

A case registration form, developed by Palestinian and Norwegian obstetricians and midwives, was used to collect data on method of delivery, parity, presentation, gestational age, mode of delivery and history of previous caesarean section.[9] Before the data collection

started, research teams in each study hospital were established, comprising the heads of obstetric departments, medical doctors, and midwives working in the labour wards. The case registration form was filled in by medical doctors or midwives who attended the births. The registered data were entered by research teams into a tailor-made version of the District Health Information Software 2 (version 2.24), which had been created by the Department of Global Infrastructure at the University of Oslo. Then data were transferred to be stored in Service for Sensitive Data (TSD) platform which is developed and operated by the University of Oslo for researchers to collect, store, analyse, and share sensitive data in compliance with the Norwegian regulations regarding individuals' privacy.

The Robson Ten Group Classification System

All women were classified according to TGCS based on the following characteristics; (1) parity (nulliparity/multiparity/multiparity with previous caesarean section), (2) number of fetuses (single/multiple), (3) presentation of the fetus (cephalic/breech/transverse), (4) onset of labour (spontaneous/induced/prelabour caesarean section), (5) gestational age (term or preterm) (table 1).

Nulliparity was defined as the woman having her first delivery, and multiparity as the woman having had one previous delivery or more. Term pregnancy was defined as having completed 37 gestational weeks or more, whereas preterm pregnancy was defined as less than 37 completed gestational weeks. Induction of labour was defined as the use of any medication, amniotomy or cervical balloon, when women were not in labour. Caesarean section rates were calculated as number of caesarean sections divided by the number of deliveries in the study population. This was calculated for the total population to find the overall caesarean section rate as well as separately for each study hospital and TGCS group.

Outcome

The primary outcome was the contributions of each group to the overall caesarean section rate. The secondary outcome was to identify the main contributors to the rate of caesarean section rates in three hospitals in Gaza, and explore differences between hospitals in the contributions of each group to the overall caesarean section rate.

Statistics

Descriptive statistics were presented as frequencies and proportions. Number of deliveries and proportion of caesarean section within each group of the TGCS were presented, and further stratified by the three study hospitals.

To assess differences in proportions of caesarean section by hospitals, $\chi 2$ tests within each TGCS group were performed. P values <0.05 were considered statistically significant. All statistical analyses were performed using SPSS V.24 (SPSS, Chicago, Illinois, USA).

Results

A total of 18 908 deliveries were included in the study. Table 2 presents differences in proportions of deliveries among TGCS groups in the study hospitals. Groups 1 and 3 (nulliparous and multiparous women with single cephalic full-term pregnancy, with spontaneous labour without previous caesarean section) were the largest groups representing 56.1% of the total study population, ranging from 49.1% in Hospital 3 to 65.6% in Hospital 1. The third largest group was Group 5 (multiparous women with single cephalic full-term pregnancy, who had already undergone at least one caesarean section), which represented 13.3% of the study population, ranging from 9.3% in Hospital 2 to 14.9% in Hospital 3. Nulliparous (Group 2) and multiparous women (Group 4) with single cephalic full-term pregnancies, who required induction of labour or underwent prelabour caesarean section accounted for 7.2% and 11.0% of the total number of deliveries, respectively. The largest variation between study hospitals was found in Group 3 ranging from 29.7% in Hospital 3 to 47.5% in Hospital 1. Groups 6–10 accounted for 12.4% of all deliveries.

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Table 2 Number of deliveries in each group of the Robson Ten Group Classification System in the study hospitals (N=18 908)

Robson Ten Group Classification System	All hospitals n (%)*	Hospital 1 n (%)*	Hospital 2 n (%)*	Hospital 3 n (%)*
1	3564 (18.9)	776 (18.1)	745 (18.3)	2043 (19.4)
2	1366 (7.2)	236 (5.5)	185 (4.6)	945 (9.0)
3	7036 (37.2)	2035(47.5)	1861 (45.7)	3140 (29.7)
4	2077 (11.0)	342 (8.0)	378 (9.3)	1357 (12.9)
5	2510 (13.3)	562 (13.1)	377 (9.3)	1571 (14.9)
6	216 (1.1)	39 (0.9)	24 (0.6)	153 (1.4)
7	355 (1.9)	78 (1.8)	82 (2.0)	195 (1.8)
8	732 (3.9)	71 (1.7)	180 (4.4)	481 (4.6)
9	8(0.0)	4 (0.1)	2 (0.0)	2 (0.0)
10	1044 (5.5)	140 (3.3)	235 (5.8)	669 (6.3)
Total	**18 908 (100)**	**4283 (100)**	**4069 (100)**	**10 56 (100)**

*n= number of deliveries in the group / total number of deliveries in the hospital/s.

A total of 4337 caesarean sections were performed, giving an overall caesarean section rate rate of 22.9%, ranging from 20.6% in Hospital 1 to 24.6% in Hospital 3 (figure 1). Women in Group 5 were the largest contributor to the overall caesarean section rate (42.6%, 1846/4337), ranging from 33.1% (283/855) in Hospital 2 to 50.7% (448/884) in Hospital 1 (figure 2, see online supplementary table 1). The second and third strongest contributors were women with multiple pregnancies (Group 8, 11.6%) and those with cephalic preterm labour (Group 10, 8.1%). Among women in Group 10 who delivered by caesarean section, 54.4% (191/351) had a history of previous caesarean section. Groups 1 and 2 (singleton nulliparous women with cephalic full term pregnancies) combined contributed 14.7% to the overall caesarean section rates ranging from 13.3% in Hospital 2 to 18.0% in Hospital 1.

Table 3 presents the caesarean section rates within each TGCS group in the study hospitals. Statistically significant differences in caesarean section rates between the TGCS groups were

observed. The caesarean section rate was lowest (3.4%) in the largest delivery group (Group 3). In the second and third largest groups, the caesarean section rate was 9.1% (Group 1) and 73.5% (Group 5), respectively. In Groups 6, 7 and 9 (breech presentation and abnormal fetal lies) more than 85% of deliveries were by caesarean section. Significant differences in caesarean section rates between study hospitals were found among women in Groups 1, 4, 5 and 7 (table 3).

Table 3 Caesarean section rates in each group of the Robson Ten Group Classification System by the study hospitals (N=18 908)

Robson Ten Group Classification System	All hospitals n (%)*	Hospital 1 n (%)*	Hospital 2 n (%)*	Hospital 3 n (%)*	P value†
1	324/3564 (9.1)	113/776 (14.6)	62/745 (8.3)	149/2043 (7.3)	<0.001
2	314/1366 (23.0)	46/236 (19.5)	51/185 (27.6)	217/945 (23.0)	0.148
3	239/7036 (3.4)	57/2035 (2.8)	73/1861 (3.9)	109/3140 (3.5)	0.148
4	236/2077 (11.4)	23/342 (6.7)	58/378 (15.3)	155/1357 (11.4)	0.001
5	1846/2510 (73.5)	448/562 (79.7)	283/377 (75.1)	1115/1571 (71.0)	<0.001
6	206/216 (95.4)	38/39 (97.4)	23/24 (95.8)	145/153 (94.8)	0.774
7	312/355(87.9)	69/78 (88.5)	79/82 (96.3)	164/195 (84.1)	0.017
8	501/732 (68.4)	45/71 (63.4)	132/180 (73.3)	324/481 (67.4)	0.213
9	8/8 (100)	4/4 (100)	2/2 (100)	2/2 (100)	N/A‡
10	351/1044 (33.6)	41/140 (29.3)	92/235 (39.1)	218/669 (32.6)	0.095
Total	4337/18 908 (22.9)	884/4283 (20.6)	855/4069 (21.0)	2598/10 556 (24.6)	

*n= number of caesarean sections in the group / total number of deliveries within the group.

†P value from Pearson χ2 test comparing caesarean section rates by hospital in each group.

‡Not applicable because the rate of caesarean section is a constant.

Within Group 5, 53.0% (1330/2510) delivered by prelabour caesarean section. Significant differences between hospitals were observed among women undergoing trial of vaginal

delivery after caesarean section. Vaginal birth after caesarean section (VBAC) ranged from 35.5% (114/321) in Hospital 1 to 65.3% (456/698) in Hospital 3 (data not shown).

Discussion

In Gaza, multiparous women with single full-term pregnancy, with at least one previous caesarean section (TGCS; Group 5), women with multiple pregnancies (Group 8) and women with preterm singletons in cephalic presentation (Group 10) were the largest contributors to the overall caesarean section rate.

Although the overall caesarean section rate in Gaza of 22.9% was relatively low compared to other continents such as 40.5% in Latin America, 32.3% in Northern America and 25.0% in Europe, it is still above the WHO criteria.[1 4] According to Robson, differences between hospitals in the distribution of groups within the TGCS may be explained by differences in data quality, or be due to significant differences in important epidemiological variables or differences in clinical practice.[10] In this cohort the study population had similar sociodemographic and obstetric characteristics.[3 9] The data collection was similar in all study hospitals, specific for this research purpose and comprised all deliveries during the study period, reducing selection bias.[3 9]

The main contributor to the overall caesarean section rate was Group 5 (women with singleton cephalic full-term pregnancy, who have undergone at least one caesarean section) having a caesarean section rate of 73.5%, although Group 5 only comprised 13.3% of all the women giving birth. In this study, the caesarean section rate in Group 5 was comparable to those seen in Latin America and Lithuania,[10 11] but lower than those in the United Kingdom and Canada, and higher than those in Ireland, Norway and Sweden.[12] Hospitals 1 and 3 had higher numbers of women in Group 5, affecting the overall caesarean section rate. The large contribution of Group 5 towards the total caesarean section rates in the study hospitals could

be explained by some women having repeated caesarean section (> 3 times). In Gaza, there is no upper limit for the number of caesarean section per woman. Moreover, there were significant differences between the study hospitals in clinical trends for VBAC, where Hospital 3 had the highest successful rate of VBAC (65.3%) among women with previous one caesarean section. This was higher than in some studies, but in line with studies from Oman and Canada, reporting successful VBAC in 67.0% and 64.3%, respectively,[13 14] and in concordance with international standards or recommendations.[15] However, the large number of caesarean sections in other TGCS groups will inevitably increase the number of women in Group 5, which will thereby become an even more important contributor to the future overall caesarean section rate. Therefore, efforts to curb the trend of rising caesarean section rates need to address this group in order to be successful. Furthermore, significant differences between hospitals in VBAC rates suggest different obstetric care practices in the study hospitals, and demonstrate the ability to increase VBAC rates by appropriate management.

In contrast to previous studies, which took place in populations with a high proportion of nulliparous women, this study was conducted in a population with a high proportion of multiparous women. Robson et al expected the contributions of Groups 1, 2 and 5 to make up two thirds of the overall caesarean section rates,[16] whereas in this study their contribution was less. Moreover, in this study, Groups 8 and 10 contributed more to the overall caesarean section rates than Groups 1 and 2 (nulliparous, full term singleton and cephalic). Groups 1, 2 and 5 contributed to around 60% of the overall caesarean section rate in this study, which was similar to some previous studies, such as in Oman, Ireland and Iceland.[12 13]

Women with multiple pregnancies (Group 8) represented 3.9 % and those with preterm labour (Group 10) 5.5% of the study population, with caesarean section rates of 68% and 34%, respectively. These groups contributed more to the overall caesarean section rates than expected by Robson.[16] This may be explained by the large number of women referred to the

study hospitals (Hospitals 1 and 3), as tertiary centers, due to in vitro fertilization treatment (IVF).[16 17] In Gaza, pregnancies resulting from IVF may be more likely to be delivered by caesarean section. Although the reason for this has not been studied, IVF pregnancies and babies may be considered more vulnerable and are therefore at higher risk for being delivered by caesarian section. Furthermore, a history of previous caesarean section in 54.4% of women who delivered by caesarean section preterm did most probably increase the caesarean section rate in this group. The differences in caesarean section rates between the study hospitals were not statistically significant for Groups 8 and 10. In previous studies these two groups were small and contributed relatively little to the overall caesarean section rate.[11 12 16 18]

Focusing on the management of nulliparous women with single cephalic full-term pregnancies (Groups 1 and 2) is important, as they represent one fourth of the obstetric population in this study. In these groups, caesarean section is usually performed due to complications of labour such as dystocia or fetal distress and should be relatively low. [11] Furthermore, variations in caesarean section rates between the study hospitals could be largely explained by variations in caesarean section rates among women in these two groups.[12] In this study, the average caesarean section rate in Group 1 (9.1%) was comparable to that reported in other studies.[11 12 16 18] However, significant differences between the study hospitals, as much as two-fold, showed differences in obstetric practice in relation to the management of spontaneous labour.

Nearly half of the study population consisted of women from Groups 3 and 4 (multipara single cephalic full-term with no previous caesarean section), which was higher than in previous studies.[12 16 18 19] These groups had less influence on caesarean section rates in all study hospitals as there were relatively few absolute medical indications for prelabour caesarean section and induction of labour was associated with low caesarean section rates.[17]

Strength and limitation

Strengths of this study include the prospective population-based cohort design. This study was the first to explore caesarean section rate in Palestine using the TGCS. All data were collected prospectively is a strength reducing the risk of information bias. Additionally, all women who gave birth in the three governmental hospitals during the study period were included, reducing the risk for selection bias.

The main limitation of the study was that women who delivered in private hospitals or in governmental hospitals the West Bank were not included.

Conclusion

Women in Groups 5, 8 and 10 contributed the most to the overall caesarean section rate in the study hospitals. Significant variations in caesarean section rates between study hospitals were observed, and may reflect differences in obstetric care. The efforts to reduce the overall caesarean section rate should be directed towards increasing VBAC in Group 5 and reducing primary caesarean section whose effect on the caesarean section rate potentiates when these women return for future delivery.[20-22]

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Contribution to authorship:

MWZ: in charge of data collection, participated in staff training on data registration and entry, statistical analysis for the data set, participated in interpretation of the results and drafted the manuscript. KL: study design, protocol and research tool development, participated in staff training on data registration and entry and commented on the manuscript. SH: study design,

collaborated in the preparation of the protocol and research tool development, data collection and participated in staff training on data registration and entry. EF: study design, protocol development and commented on the manuscript. ML: commented on the manuscript. KZ and HA-M: data collection, participated in staff training on data registration and entry and commented on the manuscript. BB: participated in interpretation of the results, revise the medical English language and commented on the manuscript. RSF: statistical analysis for the data set, participated in interpretation of the results and commented on the manuscript. AV: study design, protocol and research tool development and participated in staff training on data registration and entry, participated in interpretation of the results and commented on the manuscript.

All authors revised, comments, and approved the final version.

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Competing interest: All authors have completed the ICMJE uniform disclosure form and have no conflict of interest to declare.

Ethical approval: This study was approved by the Palestinian health research council (Reference No.: BHRC\HC\13\15), Regional Committee for Medical and Health Research Ethics in South-Eastern Norway (REK 2014/1727) and the Norwegian Data Inspectorate (17/00082-2/GRA). Oslo University Hospital signed an agreement with the Palestinian Ministry of Health which approved conducting the study within their facilities. The project was done in accordance with common rules for health care services in Palestine and Norway regarding e.g. privacy.

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Data sharing statement: No additional data are available.

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References

1. Betrán AP, Ye J, Moller A-B, et al. The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. *PloS one* 2016;11(2):e0148343.

2. Bragg F, Cromwell DA, Edozien LC, et al. Variation in rates of caesarean section among English NHS trusts after accounting for maternal and clinical risk: cross sectional study. *BMJ* 2010;341:c5065.

3. Zimmo M, Laine K, Hassan S, et al. Differences in rates and odds for emergency caesarean section in six Palestinian hospitals: a population-based birth cohort study. *BMJ Open* 2018;8(3):e019509.

4. Organization WH. Appropriate technology for birth. *Lancet* 1985;2:436-37.

5. Robson MS. Classification of caesarean sections. *Fetal Matern Med Rev.*2001;12(1):23-39.

6. Betran A, Torloni M, Zhang J, et al. WHO Statement on caesarean section rates. *BJOG* 2016;123(5):667-70.

7. Chong C, Su LL, Biswas A. Changing trends of cesarean section births by the Robson Ten Group Classification in a tertiary teaching hospital. *Acta Obstet Gynecol Scand* 2012;91(12):1422-27.

8. Ciriello E, Locatelli A, Incerti M, et al. Comparative analysis of cesarean delivery rates over a 10-year period in a single Institution using 10-class classification. *J Matern Fetal Neonatal Med* 2012;25(12):2717-20.

9. Hassan S, Vikanes A, Laine K, et al. Building a research registry for studying birth complications and outcomes in six Palestinian governmental hospitals. *BMC Pregnancy Childbirth* 2017;17(1):112.

10. Robson M. The Ten Group Classification System (TGCS)–a common starting point for more detailed analysis. *BJOG* 2015;122(5):701-01.

11. Barčaitė E, Kemeklienė G, Railaitė DR, et al. Cesarean section rates in Lithuania using Robson ten group classification system. *Medicina (Kaunas)* 2015;51(5):280-85.

12. Brennan DJ, Robson MS, Murphy M, et al. Comparative analysis of international cesarean delivery rates using 10-group classification identifies significant variation in spontaneous labor. *Am J Obstet Gynecol* 2009;201(3):308. e1-08. e8.

13. Kazmi T, Sarva Saiseema V, Khan S. Analysis of Cesarean section rate-according to Robson's 10-group classification. *Oman Med J* 2012;27(5):415.

14. Grobman WA, Lai Y, Landon MB, et al. The change in the VBAC rate: An Epidemiologic analysis. *Paediatr Perinat Epidemiol* 2011;25(1):37.

15. Russillo B, Sewitch MJ, Cardinal L, et al. Comparing rates of trial of labour attempts, VBAC success, and fetal and maternal complications among family physicians and obstetricians. *J Obstet Gynaecol Can* 2008;30(2):123-28.

16. Perinatal Services BC. Examining cesarean delivery rates in British Columbia using the Robson Ten Classification. Part 1: Understanding the Ten Groups. Vancouver, BC. December 2011;1(4)

17. Robson M, Hartigan L, Murphy M. Methods of achieving and maintaining an appropriate caesarean section rate. *Best Pract Res Clin Obstet* Gynaecol 2013;27(2):297-308.

18. Betrán AP, Gulmezoglu AM, Robson M, et al. WHO global survey on maternal and perinatal health in Latin America: classifying caesarean sections. *Reprod Health* 2009;6(1):18.

19. Nakamura-Pereira M, do Carmo Leal M, Esteves-Pereira AP, et al. Use of Robson classification to assess cesarean section rate in Brazil: the role of source of payment for childbirth. *Reprod Health* 2016;13(3):128.

20. Brennan DJ, Murphy M, Robson MS, et al. The singleton, cephalic, nulliparous woman after 36 weeks of gestation: contribution to overall cesarean delivery rates. *Obstet Gynecol* 2011;117(2, Part 1):273-79.

21. Barber EL, Lundsberg L, Belanger K, et al. Contributing indications to the rising cesarean delivery rate. *Obstet Gynecol* 2011;118(1):29.

22. Vogel JP, Betrán AP, Vindevoghel N, et al. Use of the Robson classification to assess caesarean section trends in 21 countries: a secondary analysis of two WHO multicountry surveys. *Lancet Global health* 2015;3(5):e260-e70.

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Legends:

Figure 1 Flow chart of the selected study population, multicenter study from Palestine (from 1 January 2016 until 30 April 2017).

Figure 2 Contribution of each women group within the Robson Ten Group Classification System to the overall caesarean section prevalence in the study hospitals (n=4337).

Figure 1 Flow chart of the selected study population, multicenter study from Palestine (from 1 January 2016 until 30 April 2017)

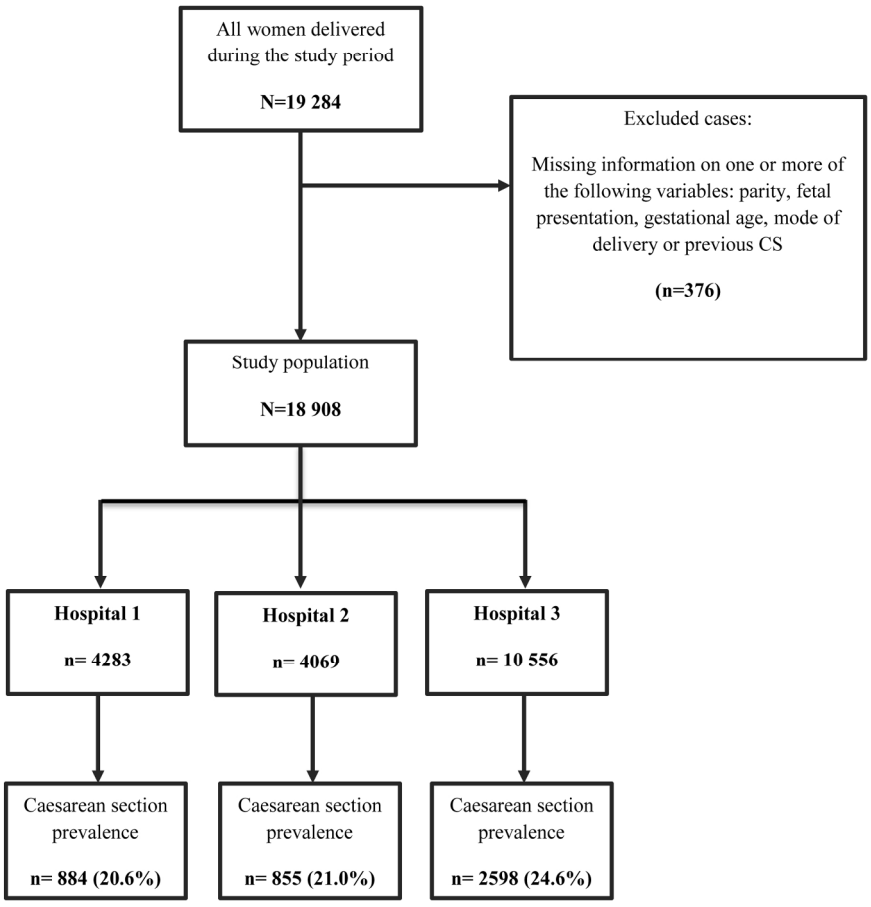

Figure 1 Flow chart of the selected study population, multicenter study from Palestine (from 1 January 2016 until 30 April 2017)

176x196mm (300 x 300 DPI)

Figure 2 Contribution of each women group within the Robson Ten Group Classification System to the overall caesarean section prevalence in the study hospitals (n=4337)

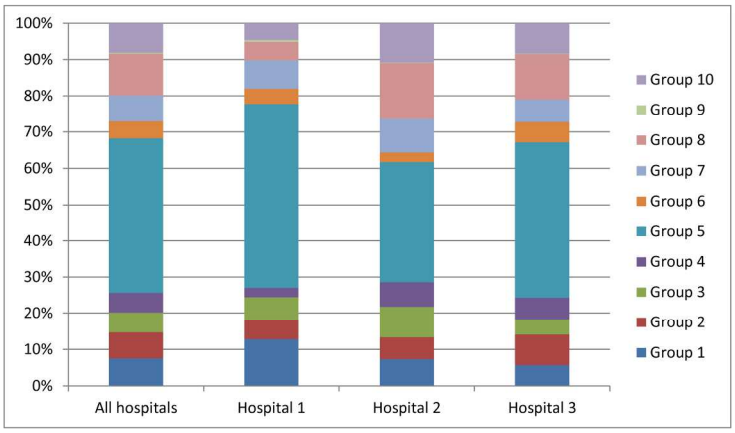

Figure 2 Contribution of each women group within the Robson Ten Group Classification System to the overall caesarean section prevalence in the study hospitals (n=4337)

210x150mm (300 x 300 DPI)

Mohammed W. Zimmo

Supplementary table 1 Contribution of each women group within the Robson Ten Group Classification System to the overall caesarean section rates in the study hospitals (n=4337)

Robson Ten Group Classification System	All hospitals n (%)*	Hospital 1 n (%)*	Hospital 2 n (%)*	Hospital 3 n (%)*
1	324 (7.5)	113 (12.8)	62 (7.3)	149 (5.7)
2	314 (7.2)	46 (5.2)	51 (6.0)	217 (8.4)
3	239 (5.5)	57 (6.4)	73 (8.5)	109 (4.2)
4	236 (5.4)	23 (2.6)	58 (6.8)	155 (6.0)
5	1846 (42.6)	448 (50.7)	283 (33.1)	1115 (42.9)
6	206 (4.7)	38 (4.3)	23 (2.7)	145 (5.6)
7	312 (7.2)	69 (7.8)	79 (9.2)	164 (6.3)
8	501 (11.6)	45 (5.1)	132 (15.4)	324 (12.5)
9	8 (0.2)	4 (0.5)	2 (0.2)	2 (0.1)
10	351 (8.1)	41 (4.6)	92 (10.8)	218 (8.4)
Total	4337 (100)	884 (100)	855 (100)	2598 (100)

*n= number of caesarean sections in the group / total number of caesarean sections in the hospital/s

P value <0.001 when compare between hospitals using $\chi 2$ test

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Within the title page 1 and design section of the abstract page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Methods and results section of abstract page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Abstract page 2 and Methods page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	pages 5 and 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	pages 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	pages 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	pages 6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	pages 5
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 6

Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 7
		(*b*) Describe any methods used to examine subgroups and interactions	Pages 7
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	Pages 7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	pages 7 and figure 1
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	N/A
		(b) Indicate number of participants with missing data for each variable of interest	Tables 2
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	Page 7, figure 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	pages 8-9; supplementary table 1
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 9, table 3
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 10-11
Limitations			Page 13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	pages 11-12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Caesarean section in Palestine using the Robson Ten Group Classification System: a population based birth cohort study

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Caesarean section in Palestine using the Robson Ten Group Classification System: a population based birth cohort study

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Abstract

Objective: To analyze the current situation of caesarean section in Palestine using the Robson Ten Group Classification System (TGCS).

Design: A population-based birth cohort study.

Setting: Obstetric departments in three governmental hospitals in Gaza.

Participants: All women (18 908) who gave birth between 1 January 2016 and 30 April 2017.

Methods: The contributions of each group to the study population and to the overall rate of caesarean section were calculated, as well as the rate of caesarean section in each TGCS group. Differences in proportions between study hospitals were assessed by $\chi 2$ test.

Main outcome measures The main outcome was the contributions of each group to the overall caesarean section rate.

Results: The overall rate of caesarean section was 22.9% (4337 of 18 908), ranging from 20.6% in Hospital 1 to 24.6% in Hospital 3. The largest contributors to the overall caesarean section rate were multiparous women with single cephalic full-term pregnancy who had undergone at least one caesarean section (Group 5, 42.6%), women with multiple pregnancies (Group 8, 11.6%) and those with single cephalic preterm labour (Group 10, 8.1%). Statistically significant differences in caesarean section rates between the study hospitals were observed in Group 1 (nulliparous women with single cephalic full-term pregnancy and spontaneous labour), Group 4 (multiparous with single cephalic full-term pregnancy with induced labour or prelabour caesarean section), Group 5 (multiparous with single cephalic full-term pregnancy with previous caesarean section) and in Group 7 (multiparous with breech presentation).

CONCLUSION: Women in Groups 5, 8 and 10 were the largest contributors to the overall caesarean section rate in the study hospitals. Efforts to reduce the differences in obstetric care between hospitals need to be directed towards increasing the proportion of vaginal births after caesarean section and by reducing primary caesarean section in multiple pregnancies and preterm labour.

Strengths and limitations of the study

- This study is the largest, population-based, prospective birth cohort study in Palestine.
- It was the first to explore caesarean section rates in Palestine using the Robson Ten Group Classification System.
- All women who gave birth in the study hospitals were included, reducing the risk for selection bias.
- The main limitation of this study was the fact that women, who gave birth in the West Bank or in the private sector in Gaza, were not included.

Introduction:

Globally, the caesarean section rate is rising continuously, making caesarean section one of the commonest surgical procedures.[1] One in five pregnant women undergoes caesarean section.[1] The caesarean section rate is often used as an indicator for the quality of healthcare, and may therefore reflect improvement of clinical governance at national and international level. However, caesarean section rates vary between countries and even between hospitals within the same country.[1-3] The World Health Organization (WHO) recommends caesarean section rates to be between 10–15%.[4] In order to investigate the underlying mechanisms for the global rise in caesarean section rates, it is fundamental to identify which groups of women are at higher risk to undergo caesarean section. For this reason, a classification system that can monitor and compare caesarean section rates in a standardized, reliable and consistent manner has been established.[5] The International Federation of Gynecology and Obstetrics (FIGO) and WHO recommend the Robson Ten Group Classification System (TGCS) as a global standard for assessing, monitoring and comparing caesarean section rates between countries and institutions.[6-8] The TGCS classifies women into 10 groups according to five obstetric characteristics that are routinely documented and easy to implement (table 1).[5] By applying TGCS, caesarean section births are being registered in relation to the women's and pregnancies' characteristics rather than medical indications.[5 6]

Table 1 The Robson Ten Group Classification System

Group	Description
1	Nulliparous, singleton, cephalic, full-term, spontaneous labour
2	Nulliparous, singleton, cephalic, full-term, induced labour or prelabour caesarean section
3	Multiparous, singleton, cephalic, full-term, without a previous caesarean section, spontaneous labour
4	Multiparous, singleton, cephalic, full-term, without a previous uterine scar, induced labour or prelabour caesarean section
5	Multiparous, singleton, cephalic, full-term, with a previous caesarean section

6	Nulliparous, singleton, breech
7	Multiparous, singleton, breech
8	Multiple pregnancy (twins or higher-order multiples)
9	Singleton, transverse or oblique lie
10	Singleton, cephalic, preterm

In Palestine, and particularly in Gaza, pregnant women receive regular antenatal care by antenatal clinics run by the United Nations Relief and Works Agency (UNRWA), the Palestinian Ministry of Health or private clinics. Care for women giving birth is offered in governmental as well as private hospitals. Governmental health services are available in all geographic areas and offer services with governmental insurance cover at very low cost.[9] Hence the majority (73.0%) of births in Gaza take place in the governmental hospitals.[9 10] The caesarean section rates in the governmental hospitals ranged from 16.6% to 26.0% in 2015.[9] The fertility rate, although falling, is currently still high in Gaza with 4.5, leading to around 55 000 births every year.[9 10] This leads to a large workload on labour and delivery wards in the Gaza-Strip, which are generally poorly equipped and do not offer single rooms, except for specific cases. Furthermore, staff numbers are low and stretched by the current workload.[10] Therefore, one-to-one care, which is an important intervention to achieve pain management as well as to prevent caesarean sections, is not available on the labour wards of governmental hospitals in Gaza.[10]

In Palestine, no hospital has used the TGCS so far. The objective of this study was to analyze the current situation of caesarean sections with use of the TGCS, and thus to identify the main contributors to the caesarean section rates in three hospitals in Gaza.

Methods:

Study design and participants

The data were obtained from a population-based birth cohort study in three Palestinian governmental hospitals in Gaza from 1 January 2016 until 30 April 2017. Two of the hospitals were teaching hospitals (Hospitals 2 and 3). Teaching hospitals in Palestine have educational programs for health personnel; such as medical doctors, midwives and nurses. Two of the hospitals were referral hospitals (Hospitals 1 and 3). Referral hospitals in Palestine receive patients from other private or governmental hospitals in the neighbouring areas. Hospital 2, being non-referral, was the only one without a maternal intensive care unit. Further characteristics of the study hospitals are presented by Sahar et al.[11]

All women, who gave birth in the study hospitals during the study period, were eligible for inclusion. Cases with unknown mode of delivery (n=373) or cases with missing information on one or more of the following variables: parity, presentation, gestational age or previous caesarean section (n=3) were excluded (figure 1).

A case registration form, developed by Palestinian and Norwegian obstetricians and midwives, was used to collect data on mode of delivery, parity, presentation, gestational age and history of previous caesarean section.[11] Before the data collection started, research teams in each study hospital were established, comprising the heads of obstetric departments, medical doctors, and midwives working in the labour wards. The case registration form was filled in by medical doctors or midwives who attended the births. The registered data were entered by research teams into a tailor-made version of the District Health Information Software 2 (version 2.24), which had been created by the Department of Global Infrastructure at the University of Oslo. Then data were transferred to be stored in Service for Sensitive Data (TSD) platform which is developed and operated by the University of Oslo for researchers to collect, store, analyse, and share sensitive data in compliance with the Norwegian regulations regarding individuals' privacy.

Patients and public involvement

There was no patient or public involvement in planning or executing this study. There are no plans to disperse the results of our research to study participants or the applicable patient community. However, results are being disseminated among the professional communities of Palestine and to policy makers, with the intent to inform future health policy decisions.

The Robson Ten Group Classification System

All women were classified according to the TGCS based on the following characteristics; (1) parity (nulliparity/multiparity/multiparity with previous caesarean section), (2) number of fetuses (single/multiple), (3) presentation of the fetus (cephalic/breech/transverse), (4) onset of labour (spontaneous/induced/prelabour caesarean section), (5) gestational age (term or preterm) (table 1).

Nulliparity was defined as the woman giving birth for the first time, and multiparity as the woman having had one previous birth or more. Term pregnancy was defined as having completed 37 gestational weeks or more, whereas preterm pregnancy was defined as less than 37 completed gestational weeks. Induction of labour was defined as the use of any medication, amniotomy or cervical balloon, when women were not in labour. Caesarean section rates were calculated as number of caesarean sections divided by the number of births in the study population. This was calculated for the total population to find the overall caesarean section rate as well as separately for each study hospital and TGCS group.

Outcome

The primary outcome was the contributions of each group to the overall caesarean section rate. The secondary outcome was to identify the main contributors to the caesarean section rates in three hospitals in Gaza, and explore differences between hospitals in the contributions of each group to the overall caesarean section rate.

Statistics

Descriptive statistics were presented as frequencies and proportions. Number of births and proportion of caesarean section within each group of the TGCS were presented, and further stratified by the three study hospitals.

To assess differences in proportions of caesarean section by hospitals, $\chi 2$ tests within each TGCS group were performed. P-values <0.05 were considered statistically significant. All statistical analyses were performed using SPSS V.24 (SPSS, Chicago, Illinois, USA).

Results

From the total number of births (18 908), 22.6% took place in Hospital 1, 21.5% in Hospital 2 and 55.8% in Hospital 3. The majority of women were aged between 21 and 30 years. Hospital 2 had the largest proportion (54.8%) of women with maternal age ≤20 years. Almost 70% of women were multiparous (Supplementary table 1).

Table 2 presents differences in proportions of births among TGCS groups in the study hospitals. Groups 1 and 3 (nulliparous and multiparous women with single cephalic full-term pregnancy, with spontaneous labour without previous caesarean section) were the largest groups representing 56.1% of the total study population, ranging from 49.1% in Hospital 3 to 65.6% in Hospital 1. The third largest group was Group 5 (multiparous women with single cephalic full-term pregnancy, who had already undergone at least one caesarean section), which represented 13.3% of the study population, ranging from 9.3% in Hospital 2 to 14.9% in Hospital 3. Nulliparous (Group 2) and multiparous women (Group 4) with single cephalic full-term pregnancies, who required induction of labour or underwent prelabour caesarean section accounted for 7.2% and 11.0% of the total number of births, respectively. The largest variation between study hospitals was found in Group 3 ranging from 29.7% in Hospital 3 to 47.5% in Hospital 1. Groups 6–10 accounted for 12.4% of all births.

Table 2 Number of births in each group of the Robson Ten Group Classification System in the study hospitals (N=18 908)

Robson Ten Group Classification System	All hospitals n (%)*	Hospital 1 n (%)*	Hospital 2 n (%)*	Hospital 3 n (%)*
1	3564 (18.9)	776 (18.1)	745 (18.3)	2043 (19.4)
2	1366 (7.2)	236 (5.5)	185 (4.6)	945 (9.0)
3	7036 (37.2)	2035(47.5)	1861 (45.7)	3140 (29.7)
4	2077 (11.0)	342 (8.0)	378 (9.3)	1357 (12.9)
5	2510 (13.3)	562 (13.1)	377 (9.3)	1571 (14.9)
6	216 (1.1)	39 (0.9)	24 (0.6)	153 (1.4)
7	355 (1.9)	78 (1.8)	82 (2.0)	195 (1.8)
8	732 (3.9)	71 (1.7)	180 (4.4)	481 (4.6)
9	8(0.0)	4 (0.1)	2 (0.0)	2 (0.0)
10	1044 (5.5)	140 (3.3)	235 (5.8)	669 (6.3)
Total	**18 908 (100)**	**4283 (100)**	**4069 (100)**	**10 56 (100)**

*n= number of births in the group / total number of births in the hospital/s

A total of 4337 caesarean sections were performed, giving an overall caesarean section rate rate of 22.9%, ranging from 20.6% in Hospital 1 to 24.6% in Hospital 3 (figure 1). Women in Group 5 were the largest contributor to the overall caesarean section rates (42.6%, 1846/4337), ranging from 33.1% (283/855) in Hospital 2 to 50.7% (448/884) in Hospital 1 (figure 2, supplementary table 2). The second and third strongest contributors were women with multiple pregnancies (Group 8, 11.6%) and those with cephalic preterm labour (Group 10, 8.1%). Among women in Group 10 who gave birth by caesarean section, 54.4% (191/351) had a history of previous caesarean section. Groups 1 and 2 (singleton nulliparous women with cephalic full term pregnancies) combined contributed 14.7% to the overall caesarean section rates, which was especially low in Hospitals 2 and 3 with 13.3% and 14.1% respectively, and it was 18.0% in Hospital 1.

Table 3 presents the caesarean section rates within each TGCS group in the study hospitals. Statistically significant differences in caesarean section rates between the TGCS groups were observed. The caesarean section rate was lowest (3.4%) in the largest group (Group 3). In the second and third largest groups, the caesarean section rates were 9.1% (Group 1) and 73.5% (Group 5), respectively. In Groups 6, 7 and 9 (breech presentation and abnormal fetal lies) more than 85% of births were by caesarean section. Significant differences in caesarean section rates between study hospitals were found among women in Groups 1, 4, 5 and 7 (table 3).

Table 3 Caesarean section rates in each group of the Robson Ten Group Classification System by the study hospitals (N=18 908)

Robson Ten Group Classification System	All hospitals n (%)*	Hospital 1 n (%)*	Hospital 2 n (%)*	Hospital 3 n (%)*	P value†
1	324/3564 (9.1)	113/776 (14.6)	62/745 (8.3)	149/2043 (7.3)	<0.001
2	314/1366 (23.0)	46/236 (19.5)	51/185 (27.6)	217/945 (23.0)	0.148
3	239/7036 (3.4)	57/2035 (2.8)	73/1861 (3.9)	109/3140 (3.5)	0.148
4	236/2077 (11.4)	23/342 (6.7)	58/378 (15.3)	155/1357 (11.4)	0.001
5	1846/2510 (73.5)	448/562 (79.7)	283/377 (75.1)	1115/1571 (71.0)	<0.001
6	206/216 (95.4)	38/39 (97.4)	23/24 (95.8)	145/153 (94.8)	0.774
7	312/355(87.9)	69/78 (88.5)	79/82 (96.3)	164/195 (84.1)	0.017
8	501/732 (68.4)	45/71 (63.4)	132/180 (73.3)	324/481 (67.4)	0.213
9	8/8 (100)	4/4 (100)	2/2 (100)	2/2 (100)	N/A‡
10	351/1044 (33.6)	41/140 (29.3)	92/235 (39.1)	218/669 (32.6)	0.095
Total	4337/18 908 (22.9)	884/4283 (20.6)	855/4069 (21.0)	2598/10 556 (24.6)	

*n= number of caesarean sections in the group / total number of births within the group

†P value from Pearson χ2 test comparing caesarean section rates by hospital in each group

‡Not applicable because the rate of caesarean section is a constant.

Within Group 5, 53.0% (1330/2510) of women gave birth by prelabour caesarean section. Significant differences between hospitals were observed among women undergoing trial of vaginal birth after caesarean section. Vaginal birth after caesarean section (VBAC) ranged from 35.5% (114/321) in Hospital 1 to 65.3% (456/698) in Hospital 3 (data not shown).

Discussion

In Gaza, multiparous women with single full-term pregnancy, with at least one previous caesarean section (TGCS; Group 5), women with multiple pregnancies (Group 8) and women with preterm singletons in cephalic presentation (Group 10) were the largest contributors to the overall caesarean section rate.

The study showed that Group 5 was one of the three major contributors, which is in line with findings in hospitals from USA, Canada, France, Lithuania, Ethiopia, Tanzania and South Africa.[12-18] But the contributions of Groups 8 and 10 in our study differ from previous studies in low and middle-income countries as well as high-income countries.[8 12-17] In most high-income countries, the major contributors to overall CS rates were Groups 5, 2 and 1.[8 15] While in studies from low-income settings such as in Ethiopia, with extremely low CS rates, the greatest contributors were Groups 1, 3 and 5.[14]

Although the overall caesarean section rate in Gaza of 22.9% was relatively low compared to other continents such as 40.5% in Latin America, 32.3% in Northern America and 25.0% in Europe, it is still above the WHO criteria.[1 4] According to Robson, differences between hospitals in the distribution of groups within the TGCS may be explained by differences in data quality, or be due to significant differences in important epidemiological variables or differences in clinical practice.[12 19] In this cohort the study population had similar sociodemographic and obstetric characteristics.[3 11] The data collection was similar in all study hospitals, specific for this research purpose and comprised all births during the study period, reducing selection bias.[3 11]

The main contributor to the overall caesarean section rate was Group 5 (women with singleton cephalic full-term pregnancy, who have undergone at least one caesarean section) having a caesarean section rate of 73.5%, although Group 5 only comprised 13.3% of all the women giving birth. In this study, the caesarean section rate in Group 5 was comparable to those seen in Latin America and Lithuania,[12 13] but lower than those in the United Kingdom and Canada, and higher than those in Ireland, Norway and Sweden.[20] Hospitals 1 and 3 had higher numbers of women in Group 5, affecting the overall caesarean section rates. The large contribution of Group 5 towards the total caesarean section rates in the study hospitals could be explained by some women having repeated caesarean section (> 3 times). In Gaza, there is no upper limit for the number of caesarean section per woman. Moreover, there were significant differences between the study hospitals in clinical trends for VBAC, where Hospital 3 had the highest successful rate of VBAC (65.3%) among women with previous one caesarean section. This was higher than in some studies,[7 21] but in line with studies from Oman and Canada, reporting successful VBAC in 67.0% and 64.3%, respectively,[22 23] and in concordance with international standards or recommendations.[24] However, the large number of primary caesarean sections in other TGCS groups will inevitably increase the number of women in Group 5, which will thereby become an even more important contributor to the future overall caesarean section rate. Therefore, efforts to curb the trend of rising caesarean section rates need to address this group in order to be successful. Furthermore, significant differences between hospitals in VBAC rates suggest different obstetric care practices in the study hospitals, and demonstrate the ability to increase VBAC rates by appropriate management.

In contrast to previous studies,[21 25] which took place in populations with a high proportion of nulliparous women, this study was conducted in a population with a high proportion of multiparous women. Robson et al and WHO expected the contributions of Groups 1, 2 and 5

to make up two thirds of the overall caesarean section rates,[19 26] whereas in this study their contribution was less. In Hospitals 2 and 3, the contributions of Group 1 and 2, to the overall CS rates were very low with 13.3% and 14.1%, respectively, although these groups make up 26.1% of the total study population. These rates were lower than in Ireland, Ethiopia and France.[14 27 28] On the other hand the contributions of Groups 8 and 10 were higher with 26.2% and 20.9%, respectively, although these groups make up only 9.4% of the total study population in this study. This may suggest that obstetric teams are good at dealing with uncomplicated pregnancies (Group 1), while demonstrating less proficiency in dealing with complicated pregnancies, such as in Groups 8 and 10. It appears that they prefer more invasive management, when faced with complicated obstetrics. This may be explained by having poor skills, poor equipment or by being understaffed to an extent that optimal care cannot be offered to these women. Also fear of litigation in the absence of professional medico-legal protection as well as a lack of routines to implement evidence based clinical practice may contribute to explain their practice. Moreover, in this study, Groups 1, 2 and 5 contributed to around 60% of the overall caesarean section rate which was similar to studies in Oman, Ireland and Iceland,[20 22] but less than other studies in Ethiopia, Italy and France.[8 14 15]

Women with multiple pregnancies (Group 8) represented 3.9 % and those with preterm labour (Group 10) 5.5% of the study population, with caesarean section rates of 68% and 34%, respectively. These groups contributed more to the overall caesarean section rates than expected by Robson and those found in previous studies.[12-18 26] This may be explained by the large number of women referred to the study hospitals (Hospitals 1 and 3), as tertiary centers, due to IVF treatment or other complications.[26 29] In Gaza, pregnancies resulting from IVF may be more likely to be delivered by caesarean section. Although the reason for this has not been studied, IVF pregnancies and babies may be considered more vulnerable and are therefore at

higher risk of caesarian section. Furthermore, a history of previous caesarean section in 54.4% of women, who gave birth by caesarean section, in Group 10, did most probably increase the caesarean section rate in this group. The differences in caesarean section rates between the study hospitals were not statistically significant for Groups 8 and 10. In previous studies these two groups were small and contributed relatively little to the overall caesarean section rate.[13 14 20 26 30]

Focusing on the management of nulliparous women with single cephalic full-term pregnancies (Groups 1 and 2) is important, as they represent one fourth of the obstetric population in this study and caesarean section in these groups will affect the future contribution of Group 5. In these groups, caesarean section is usually performed due to complications of labour such as dystocia or fetal distress and should be relatively low.[13] Furthermore, variations in caesarean section rates between the study hospitals could be largely explained by variations in caesarean section rates among women in these two groups.[20] In this study, the average caesarean section rate in Group 1 (9.1%) was comparable to that reported in other studies,[13 20 26 30] but lower than in Ireland and France.[15 28] However, significant differences between the study hospitals, as much as two-fold (ranging from 7.3% in Hospital 3 to 14.6%in Hospital 1), showed differences in obstetric practice in relation to the management of spontaneous labour.

Nearly half of the study population consisted of women from Groups 3 and 4 (multipara single cephalic full-term with no previous caesarean section), which was higher than in previous studies.[20 21 26 30] These groups had less influence on caesarean section rates in all study hospitals as there were relatively few absolute medical indications for prelabour caesarean section and induction of labour was associated with low caesarean section rates.[29] Therefore, reduction of primary caesarean sections is essential and has to be achieved by a multimodal approach including continuous staff training, increasing instrumental deliveries

among low-risk groups and reducing the variations in delivered maternity care among Palestinian hospitals. One further aspect is to increase evidence based practice among Palestinian obstetricians and midwives, which might be one of the reasons for the unusually high rates of caesarean section in Groups 8 and 10. This study and ongoing continuous audits, including the examination of caesarean section indications within TGCS groups, would contribute to the continued surveillance of obstetric practice in the government hospitals in Gaza. Furthermore, this study as well as ongoing local audits might have practical implications for health service planners to focus on the largest contributors to the overall caesarean section rate in order to standardize maternity care and improve quality of care.

Strengths and limitations

Strengths of this study include the prospective population-based cohort design. This study was the first to explore caesarean section rates in Palestine using the TGCS. All data were collected prospectively and therefore reducing the risk of information bias. Additionally, all women who gave birth in the three governmental hospitals during the study period were included, reducing the risk for selection bias.

The main limitation of the study was that women who gave birth in private hospitals or in governmental hospitals in the West Bank were not included. The study did not include caesarean section indications, which may explain the differences among hospitals in some groups.[14]

Conclusion

Women in Groups 5, 8 and 10 contributed the most to the overall caesarean section rate in the study hospitals. Significant variations in caesarean section rates between study hospitals were observed, and may reflect differences in obstetric care. The efforts to reduce the overall caesarean section rate should be directed towards increasing VBAC in Group 5 and reducing primary caesarean section.

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Contribution to authorship:

MWZ: in charge of data collection, participated in staff training on data registration and entry, statistical analysis for the data set, participated in interpretation of the results and drafted the manuscript. KL: study design, protocol and research tool development, participated in staff training on data registration and entry and commented on the manuscript. SH: study design, collaborated in the preparation of the protocol and research tool development, data collection, participated in staff training on data registration and entry and commented on the manuscript. EF: study design, protocol development and commented on the manuscript. ML: commented on the manuscript. KZ and HA-M: data collection, participated in staff training on data registration and entry and commented on the manuscript. BB: participated in interpretation of the results, revised the medical English language and commented on the manuscript. RSF: statistical analysis for the data set, participated in interpretation of the results and commented on the manuscript. AV: study design, protocol and research tool development and participated in staff training on data registration and entry, participated in interpretation of the results and commented on the manuscript.

All authors revised, comments, and approved the final version.

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Competing interest: All authors have completed the ICMJE uniform disclosure form and have no conflict of interest to declare.

Ethical approval: This study was approved by the Palestinian health research council (Reference No.: BHRC\HC\13\15), Regional Committee for Medical and Health Research Ethics in South-Eastern Norway (REK 2014/1727) and the Norwegian Data Inspectorate (17/00082-2/GRA). Oslo University Hospital signed an agreement with the Palestinian Ministry of Health which approved conducting the study within their facilities. The project was done in accordance with common rules for health care services in Palestine and Norway regarding e.g. privacy.

Data sharing statement: No additional data are available.

Figure legends

Figure 1 Flow chart of the study population, multicenter study from Palestine (from 1 January 2016 until 30 April 2017)

Figure 2 Contribution of each group in the Robson Ten Group Classification System to the overall caesarean section prevalence in the study hospitals (n=4337)

Supplementary table legends

Supplementary table 1 Sociodemographic characteristics of the study population (N=18 908)

Supplementary table 2 Contributions of each group in the Robson Ten Group Classification System to the overall caesarean section rates in the study hospitals (n=4337)

References

1. Betrán AP, Ye J, Moller A-B, et al. The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. *PloS one* 2016;11(2):e0148343.

2. Bragg F, Cromwell DA, Edozien LC, et al. Variation in rates of caesarean section among English NHS trusts after accounting for maternal and clinical risk: cross sectional study. *BMJ* 2010;341:c5065.

3. Zimmo M, Laine K, Hassan S, et al. Differences in rates and odds for emergency caesarean section in six Palestinian hospitals: a population-based birth cohort study. *BMJ Open* 2018;8(3):e019509.

4. Organization WH. Appropriate technology for birth. *Lancet* 1985;2:436-37.

5. Robson MS. Classification of caesarean sections. *Fetal Matern Med Rev.*2001;12(1):23-39.

6. Betran A, Torloni M, Zhang J, et al. WHO Statement on caesarean section rates. *BJOG* 2016;123(5):667-70.

7. Chong C, Su LL, Biswas A. Changing trends of cesarean section births by the Robson Ten Group Classification in a tertiary teaching hospital. *Acta Obstet Gynecol Scand* 2012;91(12):1422-27.

8. Ciriello E, Locatelli A, Incerti M, et al. Comparative analysis of cesarean delivery rates over a 10-year period in a single Institution using 10-class classification. *J Matern Fetal Neonatal Med* 2012;25(12):2717-20.

9. Ministry of Health P. Health Status, Palestine 2015. In Ramallah, State of Palestine 2016: 50-53, 163.

10. United Nations Population Fund, UNFPA. Palestine 2030 Demographic Change: Opportunities for Development, December 2016:55, 86.

11. Hassan S, Vikanes A, Laine K, et al. Building a research registry for studying birth complications and outcomes in six Palestinian governmental hospitals. *BMC Pregnancy Childbirth* 2017;17(1):112.

12. Robson M. The Ten Group Classification System (TGCS)–a common starting point for more detailed analysis. *BJOG* 2015;122(5):701-01.

13. Barčaitė E, Kemeklienė G, Railaitė DR, et al. Cesarean section rates in Lithuania using Robson ten group classification system. *Medicina (Kaunas)* 2015;51(5):280-85.

14. Tura AK, Pijpers O, de Man M, et al. Analysis of caesarean sections using Robson 10-group classification system in a university hospital in eastern Ethiopia: a cross-sectional study. *BMJ Open* 2018;8(4):e020520.

15. Lafitte A-S, Dolley P, Le Coutour X, et al. Rate of caesarean sections according to the Robson classification: Analysis in a French perinatal network–Interest and limitations of the French medico-administrative data (PMSI). *J Gynecol Obstet Hum Reprod* 2018;47(2): 39-44

16. Roberge S, Dubé E, Blouin S, et al. Reporting Caesarean Delivery in Quebec Using the Robson Classification System. *J Obstet Gynaecol Can* 2017;39(3):152-56.

17. Kacerauskiene J, Bartuseviciene E, Railaite DR, et al. Implementation of the Robson classification in clinical practice: Lithuania's experience. *BMC Pregnancy Childbirth* 2017;17(1):432.

18. Hehir MP, Ananth CV, Siddiq Z, et al. Cesarean delivery in the United States 2005 through 2014: a population-based analysis using the Robson 10-Group Classification System. *Am J Obstet Gynecol.* 2018; in press

19. World Health Organization. Robson Classification: Implementation Manual. Geneva: World Health Organization; 2017.

20. Brennan DJ, Robson MS, Murphy M, et al. Comparative analysis of international cesarean delivery rates using 10-group classification identifies significant variation in spontaneous labor. *Am J Obstet Gynecol* 2009;201(3):308. e1-08. e8.

21. Nakamura-Pereira M, do Carmo Leal M, Esteves-Pereira AP, et al. Use of Robson classification to assess cesarean section rate in Brazil: the role of source of payment for childbirth. *Reprod Health* 2016;13(3):128.

22. Kazmi T, Sarva Saiseema V, Khan S. Analysis of Cesarean section rate-according to Robson's 10-group classification. *Oman Med J* 2012;27(5):415.

23. Grobman WA, Lai Y, Landon MB, et al. The change in the VBAC rate: An Epidemiologic analysis. *Paediatr Perinat Epidemiol* 2011;25(1):37.

24. Russillo B, Sewitch MJ, Cardinal L, et al. Comparing rates of trial of labour attempts, VBAC success, and fetal and maternal complications among family physicians and obstetricians. *J Obstet Gynaecol Can* 2008;30(2):123-28.

25. Maneschi F, Algieri M, Perrone S, et al. Cesarean 10-group classification: a tool for clinical management of the delivery ward. *Minerva Ginecol* 2015;67(5):389-95.

26. Perinatal Services BC. Examining cesarean delivery rates in British Columbia using the Robson Ten Classification. Part 1: Understanding the Ten Groups. Vancouver, BC. December 2011;1(4)

27. Le CR, Prunet C, Deneux-Tharaux C, et al. Robson classification: A tool for assessment of caesarean practices in France. *J Gynecol Obstet Biol Reprod (Paris)* 2015;44(7):605-13.

28. Sinnott S-J, Brick A, Layte R, et al. National variation in caesarean section rates: a cross sectional study in Ireland. *PloS One* 2016;11(6):e0156172.

29. Robson M, Hartigan L, Murphy M. Methods of achieving and maintaining an appropriate caesarean section rate. *Best Pract Res Clin Obstet* Gynaecol 2013;27(2):297-308.

30. Betrán AP, Gulmezoglu AM, Robson M, et al. WHO global survey on maternal and perinatal health in Latin America: classifying caesarean sections. *Reprod Health* 2009;6(1):18.

Figure 1 Flow chart of the study population, multicenter study from Palestine (from 1 January 2016 until 30 April 2017)

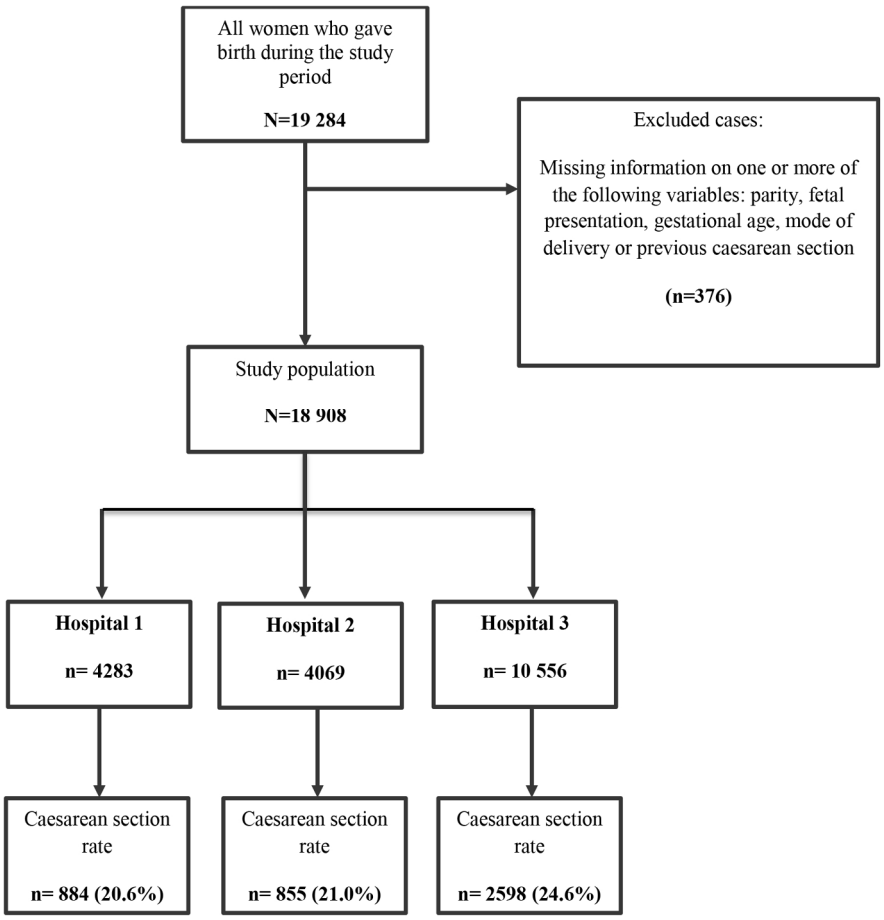

Figure 1 Flow chart of the study population, multicenter study from Palestine (from 1 January 2016 until 30 April 2017)

173x208mm (300 x 300 DPI)

Figure 2 Contribution of each group in the Robson Ten Group Classification System to the overall caesarean section prevalence in the study hospitals (n=4337)

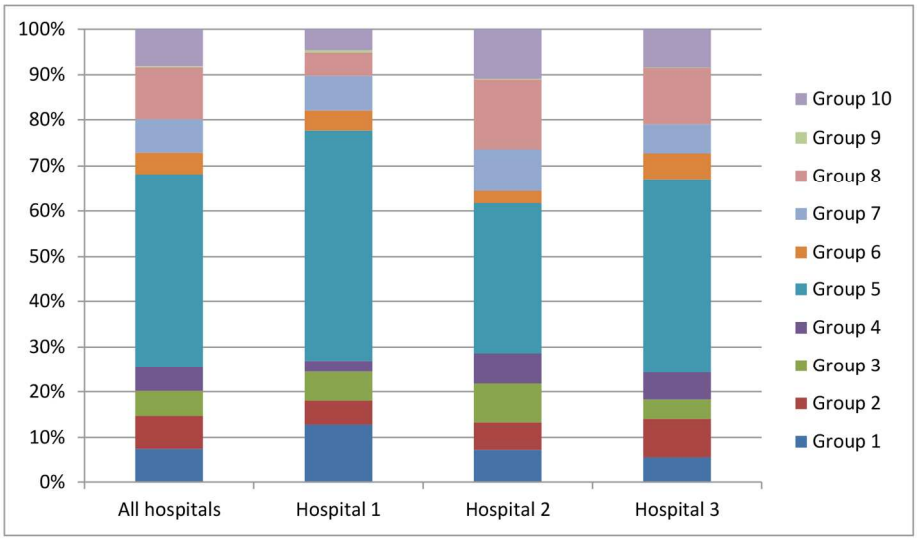

Figure 2 Contribution of each group in the Robson Ten Group Classification System to the overall caesarean section prevalence in the study hospitals (n=4337)

167x109mm (300 x 300 DPI)

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Supplementary table 1 Sociodemographic characteristics of the study population (N=18 908)

	Hospital 1 (N=4283) N (%)	Hospital 2 (N=4069) N (%)	Hospital 3 (N=10 556) N (%)	Total (N=18 908) N (%)
Maternal age				
≤20	1376 (32.1)	2230 (54.8)	2223 (21.1)	5829 (30.8)
21-30	1979 (46.2)	1338 (32.9)	6019 (57.0)	9336 (49.4)
31-40	859 (20.1)	471 (11.6)	2103 (19.9)	3433 (18.2)
>41	69 (1.6)	30 (0.7)	211 (2.0)	310 (1.6)
Education, (years)				
≤12	2513 (58.8)	3006 (73.9)	7080 (67.1)	12 612 (66.7)
13-16	1751 (40.9)	1017 (25.0)	2650 (25.1)	5418 (28.7)
≥17	14 (0.3)	44 (1.1)	820 (7.8)	878 (4.6)
Missing	5	2	6	13
Parity				
Primiparous	1117 (26.1)	1105 (27.2)	3620 (34.3)	5842 (30.9)
Multiparous	3166 (73.9)	2964 (72.8)	6936 (65.7)	13 066 (69.1)
Multiparous with previous vaginal delivery only	2521 (79.6)	2490 (84.0)	5072 (73.1)	10 083 (77.2)
Multiparous with previous one caesarean section	324 (10.2)	268 (9.0)	965 (13.9)	1557 (11.9)
Multiparous with two or more previous caesarean section	321 (10.1)	206 (7.0)	899 (13.0)	1426 (10.9)

Mohammed W. Zimmo

Supplementary table 2 Contributions of each group in the Robson Ten Group Classification System to the overall caesarean section rates in the study hospitals (n=4337)

Robson Ten Group Classification System	All hospitals n (%)*	Hospital 1 n (%)*	Hospital 2 n (%)*	Hospital 3 n (%)*
1	324 (7.5)	113 (12.8)	62 (7.3)	149 (5.7)
2	314 (7.2)	46 (5.2)	51 (6.0)	217 (8.4)
3	239 (5.5)	57 (6.4)	73 (8.5)	109 (4.2)
4	236 (5.4)	23 (2.6)	58 (6.8)	155 (6.0)
5	1846 (42.6)	448 (50.7)	283 (33.1)	1115 (42.9)
6	206 (4.7)	38 (4.3)	23 (2.7)	145 (5.6)
7	312 (7.2)	69 (7.8)	79 (9.2)	164 (6.3)
8	501 (11.6)	45 (5.1)	132 (15.4)	324 (12.5)
9	8 (0.2)	4 (0.5)	2 (0.2)	2 (0.1)
10	351 (8.1)	41 (4.6)	92 (10.8)	218 (8.4)
Total	4337 (100)	884 (100)	855 (100)	2598 (100)

*n= number of caesarean sections in the group / total number of caesarean sections in the hospital/s

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Within the title page 1 and design section of the abstract page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Methods and results section of abstract page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	page 4
Objectives	3	State specific objectives, including any prespecified hypotheses	page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Abstract page 2 and Methods page 6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	pages 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	pages 6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	pages 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	pages 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	pages 6
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 7

Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 8
		(*b*) Describe any methods used to examine subgroups and interactions	Pages 8
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	Pages 8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pages 9 and figure 1
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	N/A
		(b) Indicate number of participants with missing data for each variable of interest	Tables 2
		(c) Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	Report numbers of outcome events or summary measures over time	Page 10-11, figure 2
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	pages 8-9; supplementary table 2
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 10, table 3
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 15
Limitations			Page 13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 11-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	pages 11-12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.