

# Effect of Inhalational Anesthetics Exposure on Reproductive Outcomes and Its Predictors Among Healthcare Personnel in Jimma Zone Public Hospitals: A Comparative Cross-Sectional Study

Megersa Kelbesa Olika <sup>1</sup>, Zemenu Muluken Dessalegn<sup>1</sup>, Gezahegn Tesfaye Mekonin <sup>1</sup>, Melka Biratu Aboye<sup>1</sup>, Mitiku Berhanu Wedajo<sup>1</sup>, Tajera Tageza Ilala <sup>2</sup>, Dabessa Mosissa Abebe<sup>3</sup>, Wondu Reta Demissie <sup>4</sup>

<sup>1</sup>Department of Anesthesia, Institute of Health, Jimma University, Jimma, Ethiopia; <sup>2</sup>Department of Anesthesia, College of Medicine and Health Science, Hawassa University, Hawassa, Ethiopia; <sup>3</sup>Department of Surgery, Institute of Health, Jimma University, Jimma, Ethiopia; <sup>4</sup>Department of Biomedical Sciences, Institute of Health, Jimma University, Jimma, Ethiopia

Correspondence: Megersa Kelbesa Olika, Department of Anesthesia, Institute of Health, Jimma University, Jimma, Ethiopia, Tel +0912702005, Email megersakelbesa@gmail.com

**Background:** Emerging of anesthetics opens a new era to medical discipline in relieving patients' pain and stress when undergoing surgery but simultaneously exposes the healthcare personnel working in areas of anesthetics exposure to many adverse health effects including reproductive outcomes effects. Thus, this study aimed to assess the effect of inhalational anesthetics exposure on reproductive outcomes and its predictors among health care personnel in hospitals of Jimma zone public hospitals.

**Methods:** A comparative cross-sectional study was conducted from May 01 to 30, 2021. We approached 483 healthcare personnel in Jimma zone public hospitals to partake in this study. Of this number, we recruited 292 healthcare personnel, comprising 146 exposed healthcare personnel and 146 unexposed healthcare personnel. Structured questionnaires were used to assess the reproductive outcomes. Data were entered into EPI-data version 4.6.1 and exported to SPSS version 24 for analysis. Binary logistic regressions were carried out to identify associated factors with reproductive outcomes. Statistical significance was declared using a p value <0.05.

**Results:** The overall prevalence of bad reproductive outcome status was high (30.8%) and the prevalence was much higher among exposed HCPs (20.9%) when compared to unexposed HCPs (9.9%). Among a total of 292 HCPs the likelihood of occurred bad reproductive outcomes was higher among an exposed group (AOR=3.17, 95% CI: 1.40–7.16) and those who smoke cigarettes (AOR=8.44, 95% CI: 1.93–36.91). The occurrence rate of bad reproductive outcome was higher among 30–45h/week exposure (AOR=11.94, 95% CI: 1.25–24.95) if separately analyzed among exposed and age of couple above 41 years among unexposed (AOR=5.87, 95% CI: 1.56–22.06) were significantly associated with bad reproductive outcomes.

**Conclusion:** Prevalence of bad reproductive outcomes was higher among exposed HCPs. Hence, it requires attention to create awareness about the danger of anesthetics exposure in the study setting, suggesting the need to further minimize the exposure.

**Keywords:** inhalational anesthetics, exposure, effects, reproductive outcome, Jimma, Ethiopia

## Introduction

While one of the principal goals of anesthesia is to prevent patients from feeling pain and stress during surgery, the exposure of workers to waste anesthetic gases is a concern, because of the reported adverse effects on the health care personnel working in the potential area of inhalation anesthetic exposure.<sup>1–3</sup> This exposure occurs when inhalational

anesthetics gas is released or leaks during medical procedures in the work areas like the operating room, recovery room, delivery room, ICU, or other areas where workers may be subject to job-related exposure.<sup>4,5</sup>

Globally, it is estimated that more than 200,000 healthcare personnel may be exposed to waste anesthetics gases annually,<sup>6</sup> and mostly health care personnel like anesthesiologists, nurse anesthetists, specialists (surgical, obstetric, and orthopedic), OR nurses, operating room technicians, post-anesthesia care nurses, dentists, veterinarians are potentially exposed to waste anesthetics gases (WAGs) and are at risk of much occupational illness including adverse reproductive effects like spontaneous abortion, preterm delivery, infertility, stillbirth, congenital anomaly, premature rupture of membrane, and delay in conception to health care personnel are the main concern.<sup>7-10</sup>

Large epidemiological investigations have indicated that exposure to WAG can increase the risks of chronic diseases (eg, liver dysfunction and renal insufficiency), on top of spontaneous abortion, and congenital malformation occurring and can decrease the birth rate and increase the stillbirth rate.<sup>11</sup>

The study done in Australia shows there was a high prevalence of preterm birth in women exposed to Un scavenged anesthetic gases 7.3% compared with 5.7% in the general population.<sup>12</sup> Similarly, the study conducted at Sudan Khartoum indicates that there was a high incidence of infertility in operating room personnel 7.35% compared to 1.47% in non-exposed health workers. Higher incidence of abortion was found in operation room nurses (43.3%) while 14.29% in non-exposed health workers.<sup>13</sup>

The potential victims of this occupational hazard are health care personnel working in operating facilities with no automatic ventilation or scavenging systems or poor condition, recovery rooms/ICU where gases exhaled by recovering patients are not properly vented or scavenged, leakage in the anesthetic breathing circuit. but the severity of these anesthetics exposure hazards of adverse health effects varies according to the type of gases used, the length of exposure, and the gas concentrations.<sup>3,14-16</sup>

These potential adverse effects due to occupational chronic exposure to these compounds have led public health authorities to publish standards (guidelines and protocols) like the use of the latest inhalational agents with minimum effects, adequate ventilation of OR, use of personal protective equipment (PPE) and properly disposing of the pollutes/WAGs by scavenging system to the outside of the facilities and also develop technical procedure like sampling methods, active air treatment systems, maintenance procedures and leak test of the machinery used for anesthesia, air suctioning and air conditioning systems and medical surveillance of exposed workers to regulate the possible health effects.<sup>17-19</sup>

But these protocols are not implemented in our setup and we expect many associated health problems and high concentration of WAGs or/and their metabolites in the OR air, in the blood and urine of exposed HCPs beyond the recommended level of WHO and still, the status of adverse health effects was undefined in the setting indeed which needs to be explored and adoption of formal practices and regulations to reduce ambient air pollution in the working area to safe or minimum levels of exposure. Thus, the present study aimed to assess the impacts of occupational exposure to waste anesthetic gases on health care personnel's reproductive health by indirect measures of reproductive outcomes (inability to conceive, spontaneous abortion, delay conception, congenital malformation, stillbirth, sex ratio and compare the effect of inhalational anesthetics exposed HCPs with that of unexposed HCPs.

## Methods and Materials

### Study Design and Setting

The facility-based comparative cross-sectional study was conducted at Jimma zone public Hospital from May 1 to -30, 2021. Jimma zone is located in Oromia Regional State and is situated about 354 km away from Addis Ababa city, in the Southwest direction. There are eight public hospitals in the Jimma zone. Among the eight hospitals, seven are governed by Oromia regional state, and each of them has one operation theatre and recovery and no intensive care unit. There is one university hospital that is currently the only referral hospital in the southwestern part of the country. It has 14 major functional areas with potential anesthetics exposure [10 operation room theatres, 3 recovery rooms, and 1 main ICU] where health care personnel were potentially exposed to inhalational anesthetic hazards.

## Population and Sampling

All health care personnel working in Jimma zone public hospitals involve both exposed and unexposed HCPs with a 1:1 ratio and matched with age group, sex, and professional rank. All HCPs working more than 2 years and who married/engaged/coupled at least 1 year ago and who attempted to own children were included and while health care personnel who has a previous history of spontaneous abortion, fetal defects, low birth weight, detachment, and premature rupture of membrane, pre-term delivery and tested for infertility before entering their present occupation, and all health care personnel these previously worked in OR, ICU, x-ray room and recovery for more than 6 months were excluded. A total of 483 HCPs were sampled through surveying. Among them, only 292 HCPs were reached for final analysis, while 191 were excluded from the study based on the exclusion criteria as shown in Figure 1.

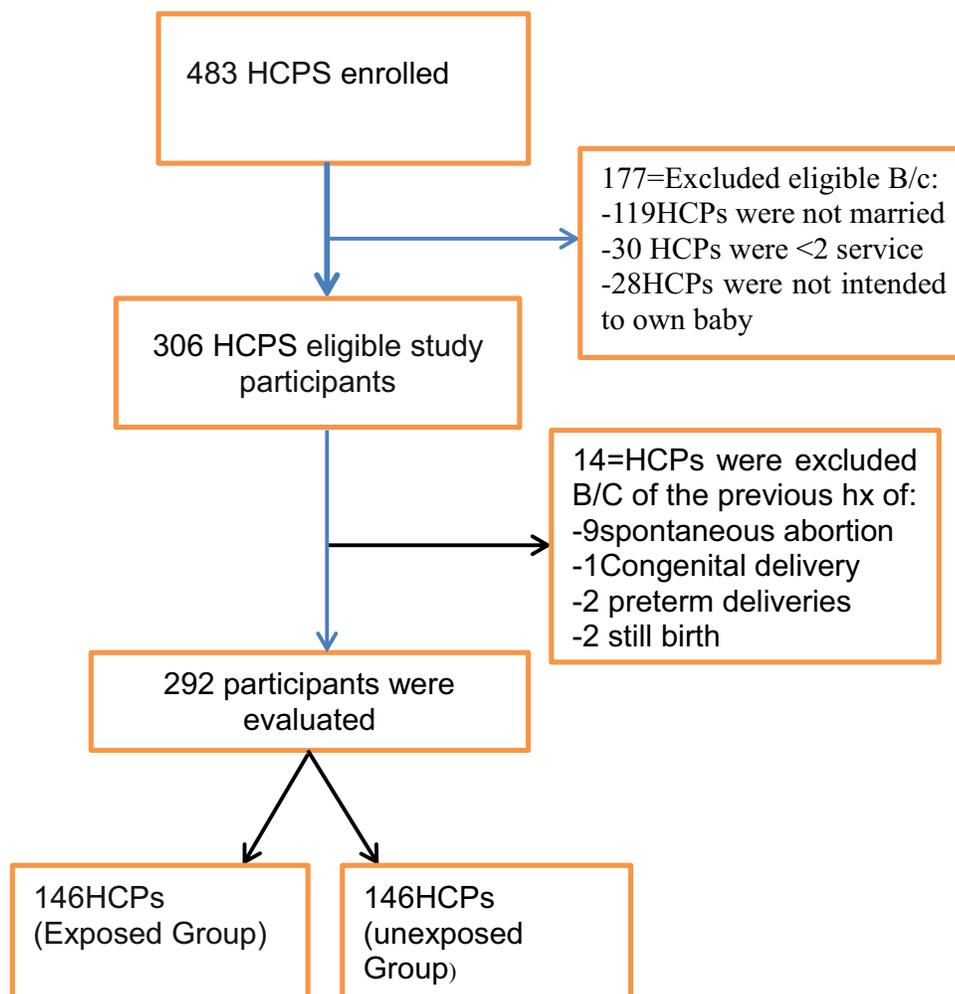
## Operational Definition

### Bad Reproductive Outcome

When health care personnel experience diverse endpoints such as the inability to conceive (infertility), delayed conception, spontaneous abortion, congenital anomaly, and the premature death of an offspring (stillbirth), and if one of these noticed, it is considered as bad reproductive outcomes.<sup>21</sup>

### Good Reproductive Outcome

When health care personnel are free of adverse reproductive health effects.



**Figure 1** Flow chart depicting reasons for research participant's exclusion.

## Data Collection Procedure and Data Quality Control

A structured questionnaire adapted from the Reproductive Toxicity Risk Assessment tools<sup>20</sup> was used to collect data about the prevalence and factors associated with the effect of anesthetics exposure on reproductive outcomes. The status of reproductive outcomes was assessed by the data collectors as a bad reproductive outcome if health care personnel experienced one of the following in their life event: inability to conceive (infertility), spontaneous abortion, congenital anomaly, delayed conception, and premature death of an offspring (stillbirth). The questionnaires include, socio-demographic characteristics; reproductive history; history of anesthetics exposure, and history of substance use were prepared in English and translated into the local language, Afan Oromo and Amharic. To check for consistency, the questionnaires were further translated from Afan Oromo and Amharic to English by another person and the questionnaires were self-administered.

Four trained diploma nurses who can speak both Afan Oromo and Amharic were recruited from the health center and supervised by two BSc nurses. One supervisor per 2 data collectors was assigned from the catchment health center.

Data collectors and supervisors were provided one-day training about the objective, the process of data collection, and field ethics and informed on how to protect themselves and participants from covid-19. Each questionnaire was checked daily by the supervisors and the principal investigator.

A pre-test was done in a non-study hospital taking 5% of the total sample size. Based on the pre-test result clarifications, and corrections were done on inconsistency, ambiguity, comprehension, and exhaustiveness questions. Problems encountered were discussed with data collectors and solved immediately.

## Data Analysis

STROBE checklist was used to analyze and report data. Each questionnaire was coded and checked manually for completeness and consistency. Then, data were entered into Epidata 4.6.1 and exported to SPSS version 24 where recording, categorizing, computing, counting, and other statistical analysis were done.

Descriptive and summary statistics were carried out to describe study participants according to different characteristics. The binary logistic regression model was fitted to identify factors associated with reproductive outcome status. Three models were fitted independently: for the whole sampled healthcare personnel (292), for the exposed healthcare personnel (146), and unexposed healthcare personnel (146). The model fitness for each model was tested by Hosmer–Lemeshow goodness of fitness, and the results of the test showed that the models were fit for every three models (P-value >0.05).

To check an interaction or effect modification of the independent variables, multi-co-linearity of the independent variables was checked using the variance inflation factor. There is no multi-co-linearity among the independent variables (VIF <10).

Using chi-square test and bivariate analysis, associations between dependent and several independent variables were examined one by one and those variables with a p-value <0.25 were entered into multivariable logistic regression. Multivariable logistic regression analysis was employed to identify factors independently associated with reproductive outcome status by controlling the effect of potential confounding variables. Odds ratio (OR) with 95% CI was computed to assess the level of association and statistical significance. Statistical significance was declared using a p-value less than 0.05. The result of this study is described in texts, tables, and graphs.

## Results

### Socio-Demographic Characteristics of Respondents

A total of 483 health care personnel exposed and unexposed to anesthesia were approached to participate in this study. Of this number, 292 HCPs were reached for final analysis, while 191 were excluded from the study. The mean age of the respondent was 32.95±6.46 years and it ranges from 21 to 59 in both groups. The highest proportion of the respondents was found in the age group 30–39 years in both groups. The majority (97) of exposed healthcare personnel have 2–5 years of service and unexposed healthcare personnel has 65 from 6 to 9 years of service. Among the eight health facilities, Jimma Medical Center (JMC) has high exposure status, which accounts for 31.2%. Nurses have the highest proportion among all professions in both groups as detailed in Table 1.

**Table 1** Socio-Demographic Characteristics Among HCPs in Jimma Zone Public Hospital, Southwest Ethiopia, 2021

Variable	Category	Exposed Group (n=146)		Unexposed (n=146)	
		Frequency	Percent	Frequency	Percent
Age group (years)	20–29	46	15.8	46	15.8
	30–39	80	27.4	80	27.4
	40–49	15	5.1	15	5.1
	>49	5	1.7	5	1.7
Sex	Male	89	30.5	89	30.5
	Female	57	19.5	57	19.5
Educational status	Diploma	16	5.5	16	5.5
	BSc	75	25.7	75	25.7
	MSc	26	8.9	26	8.9
	Specialty	25	8.6	25	8.6
	Sub-specialty	4	1.4	4	1.4
Group of profession	Anesthesia	41	14	0	0
	Gyn/obs	14	4.8	0	0
	Surgery	10	3.4	0	0
	OMF/ENT	1	0.35	0	0
	Ophthalmology	7	2.4	0	0
	Nurse	73	25	109	37.3
	Medicine	0	0	18	6.2
	Pediatrics	0	0	19	6.5
Place of work	OR	138	47.3	0	0
	PACU	2	0.7	0	0
	ICU	6	2.1	0	0
	Other wards	0	0	146	50
Year of service	2–5	97	32.2	46	17.5
	6–9	36	12.3	65	22.3
	10–15	11	3.8	33	11.3
	>15	2	0.7	2	0.7
Married/couple when	For 2 years	19	6.5	31	10.6
	Before 2 years	127	45.5	115	39.4
If married/coupled when	Before service	57	19.5	7	2.4
	At the start of service	36	12.3	33	11.3
	After service	53	18.2	106	36.3
Couple's age (years)	19–29	70	24	56	19.2
	30–40	66	22.6	74	25.3
	≥41	10	3.4	16	5.5
Couple's job	Exposed HCP	11	3.8	5	1.7
	Unexposed HCP	50	17.1	49	16.8
	NonHCP	85	29.1	92	31.55
Health facility	Jimma Medical Center	91	31.2	91	31.5
	Shenan Gibe Hospital	15	5.1	15	5.1
	Agaro Hospital	11	3.8	11	3.8
	Sekachokorsa hospital	6	2.1	6	2.1
	Dedo Hospital	7	2.4	7	2.4
	Limmu Genet Hospital	7	2.4	7	2.4
	Omo Neda Hospital	5	1.7	4	1.4
	Setama Hospital	5	1.7	4	1.4

## Reproductive History of Health Care Personnel

The majority (272 [93.2%]) of the respondent's couples experienced at least one and above pregnancy. The average number of pregnancies per woman was  $1.23 \pm 0.46$  for exposed HCPs and  $1.27 \pm 0.45$  for unexposed HCPs.

Thirty (10.3%) of the respondents exposed had experienced spontaneous abortion, of which eight (2.7%) experienced more than one spontaneous abortion after this occupational exposure. The percentage of children per exposed HCPs was 46.6%, which is slightly less than the percentage of unexposed HCPs (51.4%). Of the participants, 29.8% among exposed and 37.2% among unexposed conceived in  $\leq 6$  months, 14.3% and 12.2% in 6–12 months, and 4.4% and 2.2% were exposed to and unexposed conceived after 1 year consequently. The proportion of delivered only female children 46 (15.8%) among exposed was higher than that of unexposed 26(8.9%). A high percentage of inability to conceive was observed among exposed healthcare personnel 14(4.8%) as compared with unexposed healthcare personnel 6(2.1%). The male-to-female ratio among exposed was 0.8 while among unexposed was 2.03.

## History of Substance Use

Among the total participants, the majority (19.9%) of exposed HCPs and 26.7% of unexposed HCPs use a substance. Forty-seven (34.6%) exposed HCPs and 64 (47.1%) unexposed HCPs use alcohol. The substance used by the two groups was shisha.

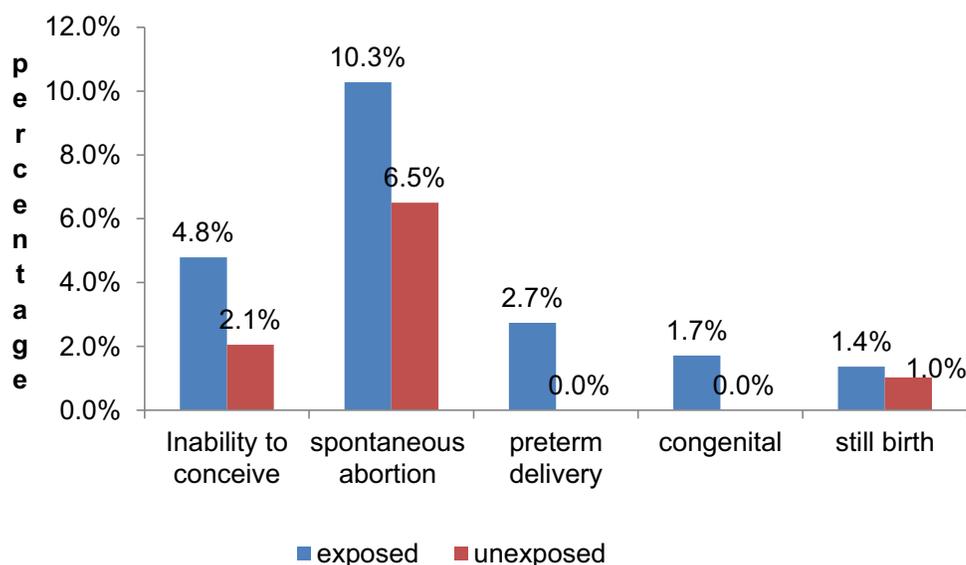
## The Overall Magnitude of Reproductive Outcomes

The overall magnitude of bad reproductive outcomes among health care personnel in Jimma zone public hospital was 30.8%, of which spontaneous abortion accounted for more than half of the remaining components of reproductive outcomes (16.8%). The comparison of reproductive outcome status components among exposed and unexposed HCPs was calculated separately (Figure 2).

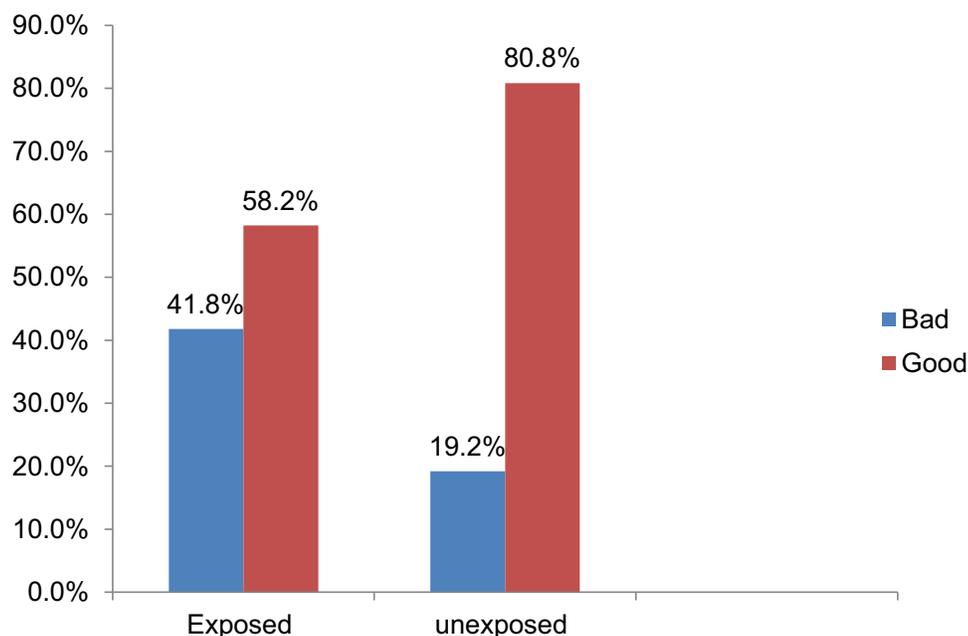
The overall magnitude of bad reproductive outcome status among health care personnel between a group and within a group, as shown below, was higher among exposed healthcare personnel (as shown in Figure 3).

## Predictors of Reproductive Outcome Status

Binary logistic regressions were applied to identify associated independent variables. To control the effect of confounders, a multiple logistic regression was done. The factors included in the model were those that showed association at the binary logistic regression analysis at a cut-off value (value  $\leq 0.25$ ) and then those in multivariable logistic regression with



**Figure 2** Specific reproductive outcome status among health care personnel in Jimma zone public hospitals, southwest Ethiopia, 2021.



**Figure 3** The comparison of reproductive outcome status among health care personnel in Jimma zone public hospitals, southwest Ethiopia, 2021.

value <0.05 were statistically significant overall factors associated with reproductive outcomes status among health care personnel (n=292).

**Bivariate Analysis Was Done Among the Whole Sample, and 10 Variables Met the Criteria for Multivariable Logistic Regression**

In multivariate analysis, the exposure status, cigarette smoking, and Depo-Provera users were independently associated with the effect of anesthetics exposure on reproductive outcomes. Accordingly, healthcare personnel who were exposed to anesthesia were 3.17 times more likely to develop bad reproductive outcomes as compared with those who were not exposed (AOR = 3.17 95% CI: 1.40–7.19, P<0.006); healthcare personnel who smoke cigarettes were 8.44 times more likely to develop bad reproductive outcomes than those who did not smoke cigarettes (AOR=8.44, 95% CI: 1.93–36.91, P<0.005); and Depo-Provera users were 6 times more likely to develop bad reproductive outcome if compared to other contraceptive users (AOR=6.01, 95% CI: 0.45–79.26, P<0.04) (Table 2).

**Table 2** Logistic Regression of Factors Associated with Reproductive Outcome Status Among Health Care Personnel in Jimma Zone Public Hospitals, Southwest Ethiopia, 2021

Variables	Category	Dependent Variable		Bivariate Result		Multivariate Result	
		Bad	Good	COR(95% CI)	P-V	AOR(95% CI)	P-V
Exposure status	Exposed	53	93	2.51(1.46–4.29)	0.002	<b>3.17(1.40–7.19)</b>	<b>0.006*</b>
	Unexposed	27	119	1			1
Age group (years)	20–29	23	73	1			1
	30–39	46	123	0.66(0.67–2.11)	0.56	0.84(0.12–5.61)	0.86
	40–49	8	14	0.67(0.67–4.86)	<b>0.23</b>	0.28(0.01–21.14)	0.56
	>49	3	2	0.74(0.05–2.78)	<b>0.09</b>		1.0

(Continued)

**Table 2** (Continued).

Variables	Category	Dependent Variable		Bivariate Result		Multivariate Result	
		Bad	Good	COR(95% CI)	P-V	AOR(95% CI)	P-V
Educational status	Diploma	9	23	0.23(0.46–1.19)	<b>0.08</b>	0.61(0.03–11.93)	0.74
	BSc	37	113	0.19(0.04–0.86)	<b>0.03</b>	0.45(0.02–7.69)	0.58
	MSc	17	35	0.42(0.08–2.02)	0.28	0.75(0.05–11.09)	0.83
	Specialty	12	38	0.17(0.03–0.84)	0.03	0.09(0.01–0.92)	0.06
	Sub-specialty	5	3				
Year of service	2–5	37	106				
	6–9	27	74	0.97(0.34–2.74)	0.95	1.27(0.02–74.75)	0.90
	10–15	15	29	1.37(0.47–4.25)	0.57	0.59(0.07–49.48)	0.81
	>15	1	3	0.88(0.07–10.3)	0.92	1.03(0.07–15.43)	
Married when	For 2 years	8	42				
	Before 2 years	72	170	2.22(0.99–4.97)	<b>0.05</b>	2.0(0.62–6.49)	0.24
When married	Before service	23	41				
	At start of service	22	47	0.83(0.40–1.71)	0.62	0.91(0.18–4.58)	0.91
	After service	35	124	0.53(0.26–0.94)	0.03	0.27(0.05–1.27)	0.09
Couple job	Exposed HCP	5	11	1.46(0.48–4.44)	0.50	1.95(0.03–124.51)	0.75
	Unexposed HCP	33	66	1.60(0.93–2.76)	0.08	0.78(0.16–3.71)	0.76
	Non-HCP	42	135				
Type of contraceptives	OCP	4	7	4.57(0.40–51.1)	0.21	13.92(0.78–47.6)	0.17
	Depo-Provera	23	80	2.30(0.27–19.3)	0.4	<b>6.01(0.45–79.26)</b>	<b>0.04*</b>
	Implanon	30	68	3.52(0.42–29.4)	0.24	6.41(0.49–83.23)	0.15
	IUD	1	8				
Use alcohol	Yes	46	65	1.82(0.70–4.71)	0.21	0.67(0.06–7.24)	0.74
	No	7	18				
Smoke cigarettes	Yes	19	7	6.06(2.33–15.7)	0.01	<b>8.44(1.93–36.91)</b>	<b>0.005*</b>
	No	34	76				

**Notes:** Bold color shows a candidate variable for multivariate analysis or p-value <0.25, and AOR and CI of statistically significant variable. \*Shows variable with statistically significant during multivariable analysis or P-value <0.05.

### Factors Associated with Reproductive Outcome Status Among Exposed Health Care Personnel

Bivariate analysis was carried out and 12 variables were associated with reproductive outcomes among exposed health care personnel. In multivariable analysis, three of them were found to be significantly associated. It was found in this study that the exposed couple HCPs were nearly 2 times more likely to develop bad reproductive outcomes if compared with an unexposed couple of healthcare personnel (AOR=1.84, 95% CI: 0.46–7.01, P<0.03). Health care personnel who had 30–45 h/w exposure were nearly 4 times more likely to develop bad reproductive outcome as compared with those who spent less hour per week in the potential area of exposure (AOR=11.94, 95% CI: 1.25–24.93, P<0.03). Anesthesia personnel was 2 times more likely to develop bad reproductive outcomes when compared with other exposed health care personnel (AOR=2, 95% CI: 0.09–9.13, P<0.042) (Table 3).

**Table 3** Logistic Regression Analysis Among Exposed Health Care Personnel in Jimma Zone Public Hospitals, Southwest Ethiopia, 2021 (n=146)

Variable	Category	Reproductive Outcome		Bivariate Result		Multivariate Result	
		Bad	Good	COR(95% CI)	PV	AOR(95% CI)	P-value
Sex	Male	28	61	1			
	Female	25	32	1.70(0.85–3.38)	0.13	3.17(1.12–8.96)	0.21
Educational status	Diploma	7	9	0.58(0.09–3.50)	0.55	1.82(0.12–27.79)	0.66
	BSc	21	39	0.40(0.08–1.97)	0.26	1.34(0.09–18.49)	0.82
	MSc	13	16	0.60(0.11–3.22)	0.56	0.81(0.09–8.80)	0.93
	Specialty	8	26	0.23(0.04–1.25)	0.09	0.47(0.05–4.26)	0.50
	Sub specialty	4	3	1		1	1
Profession	Anesthesia	15	26	2.01(0.37–10.9)	0.21	2(0.09–9.13)	<b>0.04*</b>
	Gyn/obs	11	11	3.5(0.59–20.7)	0.16	2.2(0.24–19.12)	0.49
	Nurse	19	37	1.79(0.34–9.5)	0.49	0.9(0.07–11.16)	0.92
	Surgery	6	11	1.9(0.29–12.2)	0.46	1.89(0.26–13.5)	0.52
	Ophthalmology	2	8	1		1	1
Year of service	2–5	30	67	1		1	1
	6–9	16	20	2.00(0.63–6.33)	0.23	1.08(0.35–3.35)	0.89
	10–15	6	5	3.0(0.65–13.6)	0.15	1.82(0.46–7.24)	0.39
	>15	1	1	2.50(0.13–46.7)	0.54	2.60(38–17.68)	0.32
If married when	Before service	22	35	0.95(0.44–2.06)	0.91	0.61(0.23–1.63)	0.32
	At start of service	10	26	0.58(0.23–1.46)	0.25	1.0(0.44–2.26)	0.99
	After service	21	32	1		1	1
Couple job	Exposed HCP	5	6	1.89(0.52–6.75)	0.02	<b>1.84(0.46–7.01)</b>	<b>0.03*</b>
	Unexposed HCP	22	28	1.78(0.86–3.67)	0.11	1.70(0.80–3.63)	0.16
	Non HCP	26	59	1		1	1
Substance use	Alcohol	27	20	2.36(0.60–9.18)	0.21	4.29(0.50–36.36)	0.18
	Smoke cigarettes	22	24	3.27(0.78–13.6)	0.10	8.57(0.88–74.26)	0.07
	Shisha use	2	0			–	
	Chewing khat	17	12	1	1	1	
Inhalational agent	Halothane	50	88	0.94(0.21–4.13)	0.94	0.67(0.14–3.09)	0.60
	Iso flurane	19	54	0.40(0.20–0.81)	0.01	0.38(0.07–2.09)	0.27
	Sevoflurane	0	2	1		1	

(Continued)

**Table 3** (Continued).

Variable	Category	Reproductive Outcome		Bivariate Result		Multivariate Result	
		Bad	Good	COR(95% CI)	PV	AOR(95% CI)	P-value
Service exposure h/wk	<15	2	1			1	1
	15–30	9	32	2.38(0.01–1.73)	0.49	12.17(1.47 100.18)	0.12
	31–45	21	32	0.33(0.02–3.85)	0.02	<b>3.94(1.25–24.93)</b>	<b>0.03*</b>
	>45	21	25	0.78(0.03–4.96)	0.54	–	
Status of scavenging system	Standardized	4	21	1			
	Semi secured	21	27	4.08(1.21–13.7)	0.02	5.07(0.55–46.59)	0.15
	Not secured and leaks	15	21	3.75(1.06–13.19)	0.03	1.20(0.10–13.42)	0.87

**Notes:** Bold color shows AOR or CI of statistically significant variable. \*Shows variable with statistically significant during multivariable analysis or P-value <0.05.

### Factors Associated with Reproductive Outcome Status Among Unexposed Health Care Personnel

In the bivariate analysis, the factors associated with reproductive outcomes among unexposed health care personnel entered to multivariable model and fitted. Health care personnel who smoke cigarettes were 6.53 times more likely to develop bad reproductive outcomes as compared to those who did not smoke cigarettes (AOR=6.53, 95% CI: 1.32–32.63, P<0.02) and health care personnel whose couple age is greater than 41 years were 5.87 times more likely to develop bad reproductive outcomes with those whose couple age is less than 40 years (AOR=5.87, 95% CI: 1.56–22.06, p<0.009) (Table 4).

**Table 4** Logistic Regression Analysis Among Unexposed Health Care Personnel in Jimma Zone Public Hospitals, Southwest Ethiopia, 2021 (n=146)

Variables	Category	Reproductive Outcome		Bivariate Result		Multivariate Result	
		Bad	Good	COR(95% CI)	P-V	AOR(95% CI)	P-V
Age group (years)	20–29	5	45	1		1	1
	30–39	20	66	2.77(0.97–7.90)	0.05	1.89(0.45–7.94)	0.38
	40–49	1	6	1.5(0.14–15.10)	0.73	0.76(0.04–13.33)	0.85
	>49	1	2	0.82(0.06–67.12)	0.92	1.02(0.09–93.12)	0.90
Sex	Male	22	67	1			
	Female	5	52	0.29(0.10–0.82)	0.02	5.76(1.14–24.63)	0.07
When coupled	For 2 years	3	28	1		1	1
	≥2 years	24	91	0.46(0.68–8.79)	0.16	5.76(0.59–56.28)	0.13
Age of couple (years)	19–29	9	47	1		1	1
	30–40	14	60	1.21(0.48–3.05)	0.67		
	≥41	4	12	1.74(0.45–6.63)	0.41	<b>5.87(1.56–22.06)</b>	<b>0.009*</b>
Smoke cigarettes	Yes	10	4	10.8(2.89–40.4)	0.00	<b>6.53(1.32–32.3)</b>	<b>0.02*</b>
	No	12	52	1			
Chewing khat	Yes	8	30	0.49(0.17–1.36)	0.17	0.45(0.12–1.66)	0.23
	No	14	26	1			

**Notes:** Bold color shows AOR and CI of statistically significant variable. \*Shows variable with statistically significant during multivariable analysis or P-value <0.05.

## Discussion

This study revealed the effect of inhaled anesthetics exposure and its predictors on reproductive outcomes among exposed and unexposed health care personnel in Jimma zone public hospitals. Accordingly, the overall prevalence of bad reproductive outcomes was 30.8%. The exposure type-specific prevalence of bad reproductive outcomes was 20.9% among exposed and 9.9% among unexposed healthcare personnel which shows there was a significant difference in the prevalence of bad reproductive outcomes among exposed healthcare personnel and unexposed healthcare personnel. The possible explanation for this variation may be that exposure to inhalational anesthetics may affect the reproductive outcome of exposed health care personnel compared to unexposed health care personnel. The overall prevalence of reproductive status in this study was higher as compared with the findings from a study conducted in Indonesia and Canada; the overall prevalence of reproductive status among exposed and unexposed health care personnel was 21%<sup>1</sup> and 18.7%, respectively.<sup>14</sup> This national discrepancy might be due to working environment and duration of exposure variation among the study hospitals. It also might be due to variation of anesthesia machine status, quality of scavenging system, operation room air conditioning, use of protective equipment and awareness of health care personnel to protect themselves, and the introduction of newer inhalational agents and changing anesthetic practice habits.

The overall prevalence in this study was lower than the studies conducted in Khartoum (47.2%),<sup>13</sup> Egypt (32.5%),<sup>22</sup> and Finland (33.1%).<sup>7</sup> The difference might be due to the study design variation in which the cohort and experimental study design more investigate the problem intensively than the comparative cross-sectional study.

Health care personnel that were exposed to inhalational anesthetics were associated with bad reproductive outcomes (AOR = 3.17 95% CI: 1.40–7.19,  $P < 0.006$ ). This finding was consistent with a study conducted in California at  $P < 0.007$ <sup>23</sup> and in London at  $P < 0.02$ .<sup>12</sup> A meta-analysis shows that the absence of scavenging systems reported increased risks for spontaneous abortion as a consequence of increased anesthetics exposure.<sup>17</sup> A study done in the Netherlands suggests reproductive toxicity has been the most persistent area of concern associated with occupational exposure to inhalational anesthetics. Ended the incidence of preterm delivery, congenital abnormalities, and an increased abortion rate in females exposed to waste anesthetics were high compared with unexposed groups.<sup>9</sup>

The cohort study done at Zagazig University (AOR=1.49, 95% CI: 1.04–2.13)<sup>24</sup> and in Turkey indicates that the incidence of abortion among female anesthesiologists, hospital operating room nurses, and wives of male anesthesiologists is greater than those for the normal population.<sup>25</sup> This increase in infertility, spontaneous abortion, and the risk of congenital anomalies among health personnel working in the operating room suggests that anesthetics may harm the germ cells and lead to changes in sperm morphology and motility.

Another independently associated factor among the whole and unexposed health care personnel showed smoking cigarettes were 8.44 times more likely to develop bad reproductive outcomes compared to those who did not smoke cigarettes (AOR=6.53, 95% CI: 1.32–32.31). This study is nearly similar to a study done in France (AOR=7, 95% CI 2.13–7.65).<sup>26</sup> A meta-analysis of more than 2500 men from five separate studies revealed a significant decrease in sperm concentrations of current smokers compared with those who had never smoked.<sup>18</sup>

This might be due to the effects of cigarette smoke being dose-dependent and being influenced by the presence of other toxic substances and hormonal status. Individual sensitivity, dose, time, and type of exposure also play a role in the impact of smoke constituents on human reproductive outcomes.

Depo-Provera was one of the associative risk factors for the bad reproductive outcome when compared with other contraceptive users (AOR=6.01, 95% CI: 0.45–79.26,  $P < 0.04$ ). This study is slightly higher than the study done in the UK<sup>27</sup> ( $p < 0.01$ ). This discrepancy might be the study setting difference, and the risk of this hormonal contraceptive was due to the increases in the viscosity of cervical mucus, thus creating a sticky barrier to spermatozoa and making the endometrium (the lining of the uterus) less suitable for implantation.

Being an anesthesia professional was associated with bad reproductive outcomes if compared with other health care professionals (AOR=2.22, 95% CI: 0.10–7.01,  $P < 0.03$ ). This study is higher than the study done at the University of Massachusetts medical school (AOR=2, 95% CI: 0.8–13.24).<sup>28</sup> This might be due to the anesthesia professionals being closely exposed than any other exposed health care personnel, the difference might be due to the study setting and the inhalational agents.

Health care personnel who were exposed to inhalation anesthetics for 30–45 h/W were nearly 4 times more likely to develop bad reproductive than those who have lower frequency exposure among exposed (AOR=11.94, 95% CI: 1.25–24.93,  $P<0.03$ ). This study is higher than the study done in the Netherlands<sup>9</sup> and Australia.<sup>12</sup> The difference might be due to the shortage of health care personnel manpower and this increases the long hour working in the area of anesthetic exposure in the study setting.

Other associated factors of bad reproductive outcomes among exposed healthcare personnel were being a couple of exposed healthcare personnel. This finding is in line with the study conducted in the USA<sup>29</sup> and in India.<sup>30</sup> Health care personnel whose paternal age is greater than 41 years were more likely to develop bad reproductive outcomes when compared with health care professionals whose age is less than 40 years. This study is similar to the study done in Canada<sup>15</sup> which suggests, that aging has a negative consequence on reproductive outcomes. Another study done in Singapore and Israel supports that paternal age greater than 40 years was a risk factor for bad reproductive outcomes. This is due to the decreased number of oocytes as well as oocyte quality, and the decreased number and quality of semen, giving rise to lower fertilization and implantation rates, with fewer cycles reaching embryo transfer.<sup>27</sup>

## Conclusion

The prevalence of bad reproductive outcomes was higher among exposed healthcare personnel if compared with unexposed healthcare personnel. Among the components of bad reproductive outcomes, spontaneous abortions were the dominant bad reproductive outcome experienced among exposed respondents and the delay of conception was 2 times fold increase among the exposed. The male-to-female ratio is low among the exposed group.

## Abbreviations

ACGIH, American Conference of Governmental Industrial Hygienists; AOR, adjusted odds ratio; COR, crude odds ratio; ETT, endotracheal tube; HCPs, health care personnel; ICU, intensive care unit; IAG, inhalational anesthetic gas; JMC, Jimma Medical Center; NIOSH, National Institute for Occupational Safety and Health; N<sub>2</sub>O, nitrous oxide; OR, operating room; PACU, post anesthesia care unit; PPE, personnel protective equipment's; SPSS, Statistical Package for Social Science; WAG, waste anesthetic gases; WHO, World Health Organization; VIF, variable inflation factor.

## Data Sharing Statement

The datasets used during the current study were available by requesting the corresponding author for a reasonable quest.

## Ethics Approval and Consent to Participate

Ethical clearance was obtained from Jimma University Ethical Review Board. The study also maintained the protocol of the Helsinki declaration. A letter of permission was obtained from Jimma Medical Center and the Jimma Zone Health Office for all hospitals in the zone. Informed consent was taken from each participant, and confidentiality was maintained by excluding the name of participants from the questionnaire and keeping the privacy of individual participants.

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## Author Contributions

All authors made a significant contribution to the study conception, design, execution, acquisition of data, analysis or interpretation of data, or in all these areas. All authors took part in drafting, revising, or critically reviewing the article. All authors gave final approval of the version to be published, have agreed on the journal to which the article has been submitted, and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declared that there are no competing interests.

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